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For: MOVING PICTURE CODING METHOD AND MOVING PICTURE DECODING METHOD

VERIFICATION OF TRANSLATION

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

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declares:

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(2) that she translated Japanese priority document JP2003-040805 from Japanese to English;

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(4) that all statements made of her own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and that such false statements may jeopardize the validity of the application or any patent thereon.

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[Title of the Invention]

IMAGE CODING METHOD AND IMAGE DECODING METHOD

[Claims]

[Claim 1]

An image coding method for coding an image signal on a picture-by-picture basis, said image coding method comprising

outputting flag information A, when values indicated by display order information of a picture and display order information of a picture immediately before the picture are non-sequential, to a point immediately before the picture, the flag information A indicating that the values indicated by the display order information are non-sequential.

[Claim 2]

An image decoding method for decoding an image signal that is coded on a picture-by-picture basis, said image decoding method comprising

managing a display order of each picture such that the display order of the picture immediately before the flag information in decoding order precedes a picture after the flag information A in the decoding order, when the flag information A indicates non-sequentiality of the display order.

[Claim 3]

An image coding method for coding an image signal on a picture-by-picture basis, said image coding method comprising

outputting flag information B, when an image coding signal is output which instructs to compensate non-sequentiality of referenced picture numbers by inserting a specific picture having no actual decoded image, and when the referenced picture number of a certain picture and the referenced picture number of the picture immediately before the certain picture are non-sequential, the flag information B instructing not to perform the compensation.

[Claim 4]

An image decoding method for decoding an image signal that is coded on a picture-by-picture basis, said image decoding method

comprising

not inserting a specific picture having no actual image, when flag information B indicates non-sequentiality of referenced picture numbers.

[Claim 5]

An image coding method for coding an image signal on a picture-by-picture basis, said image coding method comprising

coding, on a basis of the pictures collected to be sequential in display order, such that a display order of a given picture in a unit precedes a display order of a given picture in a unit immediately after the unit in the order of coding the unit.

[Claim 6]

An image coding method for coding an image signal on a picture-by-picture basis, said image coding method comprising

assigning information indicating a position of a first picture independently decodable in the unit into a random access unit, on a basis of the random access unit into which the pictures are collected.

[Claim 7]

A recording medium on which a program for performing the image coding method according to Claim 1 is recorded, the program causing a computer to execute

the image coding method for coding the image signal on the picture-by-picture basis, the image coding method including

outputting flag information A, when values indicated by display order information of a picture and display order information of the picture immediately before the picture are non-sequential, to the point immediately before the picture, the flag information A indicating that the values indicated by the display order information are non-sequential.

[Claim 8]

A recording medium on which the program for performing the image decoding method according to Claim 2 is recorded, the program causing a computer to execute

the image decoding method for decoding the image signal that is coded on the picture-by-picture basis, the image decoding method

including

managing the display order of each picture such that the display order of the picture immediately before the flag information in decoding order precedes the picture after the flag information A in the decoding order, when the flag information A indicates non-sequentiality of the display order.

[Claim 9]

A recording medium on which a program for performing the image coding method according to Claim 3 is recorded, the program causing a computer to execute

the image coding method for coding the image signal on the picture-by-picture basis, the image coding method including

outputting flag information B, when an image coding signal is output which instructs to compensate non-sequentiality of referenced picture numbers by inserting the specific picture having no actual decoded image, and when the referenced picture number of the certain picture and the referenced picture number of the picture immediately before the certain picture are non-sequential, the flag information B instructing not to perform the compensation.

[Claim 10]

A recording medium on which a program for performing the image decoding method according to Claim 4 is recorded, the program causing a computer to execute

the image decoding method for decoding the image signal that is coded on the picture-by-picture basis, the image decoding method including

not inserting the specific picture having no actual image, when the flag information B indicates non-sequentiality of referenced picture numbers.

[Claim 11]

A computer-readable recording medium on which a program for performing the image decoding method according to Claim 5 is recorded, the program causing a computer to execute

the image coding method for coding the image signal on the picture-by-picture basis, the image coding method including

coding, on a basis of the pictures collected to be sequential in display order, such that the display order of the given picture in the unit precedes the display order of the given picture in the unit immediately after the unit in the order of coding the unit.

[Claim 12]

A computer-readable recording medium on which a program for performing the image decoding method according to Claim 6, the program causing a computer to execute

the image coding method for coding the image signal on the picture-by-picture basis, the image coding method including

assigning information indicating the position of the first picture independently decodable in the unit into the random access unit, on the basis of the random access unit into which the pictures are collected.

[Detailed Description of Invention]

[0001]

[Technical Field]

The present invention relates to a image coding method for coding a image signal on a picture-by-picture basis, a image decoding method for decoding the coded image signal, and a program for executing these methods as software.

[0002]

[Related Art]

Recently, with an arrival of the age of multimedia which handles integrally audio, video and pixel values, existing information media, i.e., newspaper, journal, TV, radio and telephone and other means through which information is conveyed to people, has come under the scope of multimedia. In general, multimedia refers to a representation in which not only characters but also graphic symbols, audio and especially pictures and the like are related to each other. However, in order to include the aforementioned existing information media in the scope of multimedia, it appears as a prerequisite to represent such information in digital form.

[0003]

However, when estimating the amount of information contained in each of the aforementioned information media in digital form, the information amount per character requires 1 to 2 bytes whereas audio requires more than 64 Kbits per second (telephone quality) and when it comes to a moving picture, it requires more than 100Mbits per second (present television reception quality). Therefore, it is not realistic to handle the vast information directly in digital form via the information media mentioned above. For example, a videophone has already been put into practical use via Integrated Services Digital Network (ISDN) with a transmission rate of 64 Kbits/s to 1.5 Mbits/s, however, it is impossible to transmit a picture captured on the TV screen or shot by a TV camera.

[0004]

This therefore requires information compression techniques, and for instance, in the case of a videophone, video compression

techniques compliant with H.261 and H.263 Standards recommended by International Telecommunication Union-Telecommunication Standardization Sector (ITU-T) are employed. According to the information compression techniques compliant with MPEG-1 standard, picture information as well as audio information can be stored in an ordinary music CD (Compact Disc).

[0005]

Here, Moving Picture Experts Group (MPEG) is an international standard for a compression of moving picture signals and the MPEG-1 is a standard that compresses video signals down to 1.5 Mbit/s, namely, to compress the information included in TV signals approximately down to a hundredth. The quality targeted in the MPEG-1 standard was a medium one so as to realize a transmission rate primarily of about 1.5 Mbits/s, therefore, MPEG-2, standardized with the view to meet the requirements of even higher quality picture, realizes a TV broadcast quality for transmitting moving picture signals at a transmission rate of 2 to 15 Mbits/s.

[0006]

In the present circumstances, a working group (ISO/IEC JTC1/SC29/WG11) previously in charge of the standardization of the MPEG-1/MPEG-2 has further standardized MPEG-4 which achieves a compression rate superior to the one achieved by the MPEG-1/MPEG-2, allows coding/decoding operations on a per-object basis and realizes a new function required by the age of multi media. At first, in the process of the standardization of the MPEG-4, the aim was to standardize a low bit rate coding, however, the aim is presently extended to a more versatile coding including a high bit rate coding for interlaced pictures and others. Moreover, a standardization of MPEG-4 AVC and ITU H.264, as a next generation coding method, is in process with a higher compression rate, jointly worked by the ITU-T and the ISO/IEC. The next generation coding method is published under the name of Committee Draft (CD) as of August 2002.

[0007]

In general, in coding of a moving picture, compression of information volume is performed by eliminating redundancy both in

spatial and temporal directions. Therefore, an inter-picture prediction coding, which aims at reducing the temporal redundancy, estimates a motion and generates a predictive picture on a block-by-block basis with reference to forward and backward pictures, and then codes a differential value between the obtained predictive picture and a current picture to be coded. Here, “picture” is a term to represent a single screen and it represents a frame when used for a progressive picture whereas it represents a frame or a field when used for an interlaced picture. The interlaced picture here is a picture in which a single frame consists of two fields respectively having different time. For coding and decoding an interlaced picture, three ways are possible: processing a single frame either as a frame, as two fields or as a frame / field structure depending on a block in the frame.

[0008]

A picture to which an intra-picture prediction coding is performed without reference pictures is called an “I-picture”. A picture to which the inter-picture prediction coding is performed with reference to a single picture is called a “P-picture”. A picture to which the inter-picture prediction coding is performed by referring simultaneously to two pictures is called a “B-picture”. The B-picture can refer to two pictures, arbitrarily selected from the pictures whose display time is either forward or backward to that of a current picture to be coded, as an arbitrary combination. The reference pictures can be specified for each block which is a basic unit for coding and decoding, but they can be classified as follows: the first reference picture for a reference picture that is described first in the bit stream on which coding is performed; and the second reference picture for a picture that is described later. However, the reference pictures need to be already coded or decoded as a condition to code or decode these I, P and B pictures.

[0009]

A motion compensation inter-picture prediction coding is employed for coding P-pictures or B-pictures. The motion compensation inter-picture prediction coding is a coding method in which motion compensation is applied to inter-picture prediction

coding. The motion compensation is not a method to simply predict motions using pixels in the reference picture but to estimate a motion (to be referred to as a "motion vector" hereinafter) at each part within a picture and improve accuracy in prediction by performing prediction that takes a motion vector into consideration as well as to reduce the data amount. For example, the amount of data is reduced by estimating a motion vector for a current picture to be coded and coding prediction error between a predictive value, which is obtained after being shifted for the amount equivalent to the motion vector, and the current picture. In the case of using this method, information on motion vectors is required at the time of decoding, therefore, the motion vectors are coded and then recorded or transmitted.

[0010]

The motion vector is estimated on a macroblock-by-macroblock basis. To be precise, the motion vector is estimated by fixing a macroblock in the current picture, shifting a macroblock in the reference picture within a search range and then finding out a location of the reference block that resembles a basic block the most.

[0011]

FIG. 13 shows concepts of Picture Order Count (POC) and a frame number (FN) defined in JVT. The POC indicates an order in which the pictures are displayed. However, it does not indicate an actual display time. For example, the POC of a picture IDR19 in the diagram indicates "0" while the POC of the following picture B20 indicates "1". This shows that the picture B20 is to be displayed following the picture I19 but does not show the period of time that passes until the picture is displayed. The actual display time can be obtained from data associated with each of the pictures and is managed by an apparatus which functions independently from a video decoder (an image decoding apparatus). The POC is always reset to "0" at an IDR picture, a special intra picture, and is assigned to each of the pictures so that the value increases picture by picture in display order. The POC is reset again to "0" when the value reaches to a predetermined maximum value. The example in the diagram shows that the POC returns to the value "0" at IDR pictures IDR19, IDR29,

and also at the picture B24 after having completed the cycle, when the maximum value of the POC is set to “4”.

[0012]

The FN is the numbers to be assigned to the pictures which may be referred to later on. (A) in the diagram shows a state of the memory before the picture B21 is decoded, where three reference pictures are stored. (B) in the diagram shows the state after the picture B21 is decoded and stored in the memory. Here, the FN of the picture B21 has the same value as that of a picture P25 which is to be decoded next. However, when plural consecutive pictures in decoding order have the same FN, this means that the last picture, not the other pictures, in decoding order is a reference picture. According to this example, the picture B21 is not a reference picture, therefore, when being stored in the memory, the picture B21 is marked as “unused as a reference picture” (the state of being marked is presented as “unused”).

[0013]

When a reference picture is stored in the memory, it is marked as “used as a reference picture” (the state of being marked is presented as “used”). It should be noted that whether or not a picture is a reference picture is indicated in a field called “nal_ref_idc” included in the coded stream, however, this is not explained here since it does not relate directly to the description of the present invention. The frame number FN is also reset to “0” at IDR pictures as well as when the value reaches the predetermined maximum value, as is the case of the display order information POC. The example shows that the FN is reset to “0” at the pictures IDR19 and IDR29 as well as at the picture B24.

[0014]

Next, the operation of removing pictures with the view to allocate a free space in the memory is explained with reference to FIGS. 14 and 15. FIG. 14 shows the removing operation in the case where the memory has the picture marked as “unused”. The decoded pictures I23, P22, B20 and B21 are stored in the memory immediately before the picture P23 is decoded while the picture B21 is already

marked as “unused” since it is not a reference picture (see (A) in the diagram). Then, the pictures are marked as “unused”, if necessary, using a method such as a memory management control operation (MMCO) or a sliding window which determines a picture, which is stored in the memory at the earliest time, as unnecessary. These operations are called unused marking processing in the present specification. Here, the picture P22 is marked as “unused” (see reference to (B) in the diagram). Then, a picture is removed in order to allocate a free space. When plural used pictures are stored in the memory as shown in (B), the picture located in the earliest position in display order is removed. In this case, the display order information of the picture P22 indicates “3” while the display order information of the picture B20 indicates “1”, therefore, the picture B20 is removed (see reference to (C) in the diagram). The picture P23 is stored in the area released as a result of the removing (see reference to (D) in the diagram).

[0015]

It should be noted that a picture includes a frame and a field. Although the term “picture” is employed in the present specification, a picture may be stored in the memory on a frame-by-frame basis (an odd field and an even field of the same time). Similarly, a picture may be removed on a frame-by-frame basis for allocating a free space in the memory.

[0016]

It should be also noted that the number presented with the term “stage” in the diagram indicates a stage of transition of the memory. 1 is a stage before the unused marking processing is operated in processing the picture and 2 is a stage after the unused marking processing is operated while 3 is a stage after a free space is allocated and 4 is a stage after the picture is stored.

[0017]

FIG. 15 shows the removing operation when the memory does not have the picture marked as “unused”. As shown in the diagram, the pictures are decoded in order as follows: I19, P22, B20, B21 and P23. As shown in (A) in the diagram, the pictures I19, P22, B20 and

B21 are stored in the memory at the stage before the picture P23 is decoded and any of these pictures is not marked as "unused". Then, as shown in (B) in the diagram, it is assumed that none of the pictures is marked as "unused" in the unused marking processing. As in this case, when the memory has no such pictures marked as "unused", the picture firstly decoded out of all the pictures stored in the memory is removed in order to allocate a free space. As shown in (C) in the diagram, the picture I19 is removed here since it is the picture firstly decoded among the pictures stored in the memory. Lastly, as shown in (D) in the diagram, the decoded picture P25 is stored in the released area.

[0018]

FIG. 16 is a block diagram showing the structure of the conventional decoding apparatus. The variable length decoding unit VLD performs variable length decoding by VLC on the inputted coded image signal Str while the picture decoding unit PicDec decodes the coded picture data and stores a decoded picture signal Recon in the memory MEM. When the picture is inter-picture coded, the picture decoding unit PicDec needs to output motion information MV to the memory MEM, and generates a motion compensated reference picture MCPic. The memory management unit MemCtrl outputs instructions mctrl for managing the memory such as determination of an area for storing a picture, retention of a free space, and others. The display order information POC is outputted from the variable length decoding unit VLD to the memory management unit MemCtrl and is kept there. An MMCO command MMCO, which is one of the unused marking processing as mentioned above, is inputted from the variable length decoding unit VLD to the MMCO command decoding unit MMCODec, and decoded while the instruction to mark "unused" is inputted to the memory management unit MemCtrl. A decoded picture signal Vout to be displayed is outputted from the memory MEM.

[0019]

FIG. 17 is a flowchart showing the memory-related operation performed by the conventional decoding apparatus. The present flow shows the operation on a picture-by-picture basis in Steps S1 through

S2. The image decoding apparatus performs unused marking processing and marks "unused", if necessary, for each of the pictures stored in the memory (Step S13). The image decoding apparatus then performs processing of allocating a free space, allocates a free space in the memory (Step S14) and stores the decoded picture signal Vout in the free space (Step S15).

[0020]

FIG. 18 is a flowchart showing the operation for allocating a free space performed by the conventional decoding apparatus and explaining in detail Step S14 in FIG. 17. In the processing of allocating a free space (Step S14), the image decoding apparatus examines whether or not the memory MEM has the picture marked as "unused" (Step S141). When the memory MEM has such picture, a picture, which is displayed at the earliest time among the pictures marked as "unused" stored in the memory MEM, is removed (Step S143). When the memory MEM does not have any such pictures, the picture that is firstly decoded among the pictures stored in the memory MEM is removed (Step S142).

[0021]

FIG. 20 is a conceptual diagram describing the operation of dummy picture processing. The JVT defines the operation of the memory management that when a part of the sequence of pictures inputted by the decoder is lost, dummy pictures are inserted for the number corresponding to the lost pictures. This operation is performed by the decoder when "required_frame_num_update_behaviour_flag" included in the sequence parameter set indicates "1". The dummy picture is a specially marked picture having no actual decoded picture signal, and cannot be used for reference. It is assumed that the status, as shown in the figure, of the memory after having decoded the pictures I19, P20, P22 and P23 is as shown in (A) of the diagram. When decoding the following picture B25, a reference index used for specifying a reference picture is assigned in such a manner that a small value of the reference index ref_idx is assigned to the picture that is decoded last in decoding order and not marked as "unused". The assignment

of the reference index as described above is only an example and the way of assigning differs depending on a picture type or the like, while having the dependent nature of assigning the index of reference relations with dependency on the pictures stored in the memory is the same. In the example shown in the diagram, "ref_idx = 0" is assigned to the picture P22 which is decoded lastly and is not marked "unused" while "ref_idx = 1" is assigned to the picture P21 which is decoded immediately before the picture P22 and is not marked as "unused".

[0022]

Here, when the pictures P21 and P24 are lost during the transmission, or in other cases, and are not inputted in the decoder, the reference indices ref_idx are assigned to the reference pictures, as shown in (B) in the diagram, for decoding the picture B24, unless the dummy pictures are inserted. Basically, "ref_idx = 0" and "ref_idx = 2" are respectively assigned to the pictures P22 and P20 which are referred to by the picture B24. Since "ref_idx = 0" is assigned to the picture P22 and "ref_idx = 2" is assigned to the picture I19, it is a problem that the picture I19 instead of the picture P20 might be referred to by mistake. In order to avoid this, the dummy pictures are inserted.

[0023]

(C) In the diagram shows a state of the memory before the picture B24 is decoded in the case in which the dummy pictures are inserted. When the non-sequentiality in frame numbers FN is detected, the dummy pictures are inserted for the number corresponding to the number of the lost pictures. In the example, when the picture P22 with the FN indicating "3" is decoded, the FN of the picture P20, which is decoded immediately before the picture P22, indicates "1". The number thus increases by 2 while it increases normally by 1, which shows that one picture is lost. Therefore, one dummy picture is inserted before the picture P22 is decoded. The dummy picture as described above being a special picture is marked as "used" although it does not have an actual decoded picture signal and is processed as a reference picture at the time of assigning the

reference indices to the pictures. The dummy picture, however, is further marked as "non-existent (non-exist)" because it shall not be used actually for reference.

[0024]

FIG. 21 is a block diagram showing the structure of the conventional decoding apparatus. The decoding apparatus includes an FN gap detection unit FNGapDet and the memory management unit MemCtrlB operates differently, which are different from the image decoding apparatus described in FIG. 16. The FN gap detection unit FNGapDet obtains a frame number FN from the variable length decoding unit VLD, and instructs the memory management unit MemCtrlB to insert the dummy pictures for the required number, when the gap is detected. The memory management unit MemCtrlB stores, in the memory MEM, the dummy pictures for the number instructed by the FN gap detection unit FNGapDet.

[0025]

FIG. 22 is a flowchart showing the dummy picture processing operated by the conventional decoding apparatus. The difference in the memory-related operation between the present image decoding apparatus and the one described in FIG. 17 is that the former examines a gap between the frame numbers FN (Step S11) before the unused marking processing takes place (Step S13). When the gap is detected, the image decoding apparatus proceeds to Step S13 after having stored the dummy pictures for the number corresponding to the number of the missing pictures (Step S12). When the gap is not detected, the image decoding apparatus proceeds to Step S13. In Step S12, the image decoding apparatus stores the dummy pictures for the number of the missing pictures in the same manner as the normal procedure used in storing a picture shown in FIG. 17.

[0026]

FIG. 24 is a conceptual diagram showing the conventional structure of the stream according to MPEG-2. As shown in the diagram, the stream according to MPEG-2 has a layered system. The stream is made up of a plurality of Group Of Pictures (GOP). It is possible to edit a moving picture and to perform random access on it

by using the GOP as a basic unit used in coding processing. The Group Of Picture consists of a plurality of pictures, each being I-picture, P-picture and B-picture. The stream, GOP and picture respectively include a synchronous signal (sync) indicating a boundary between respective units and a header that is data commonly included in the respective units. In MPEG-2, P-picture can be predictive-coded with reference to one picture, either I-picture or P-picture, whose display time immediately precedes that of the P-picture.

[0027]

In addition, B-picture can be predictive-coded with reference to one picture whose display time immediately precedes the B-picture or one picture whose the display time immediately follows the B-picture, both of which can be either I-picture or P-picture. The position of the B-picture is arranged in the stream, either immediately after I-picture or P-picture. Therefore, at the time of performing random access, all the pictures which are located after I-picture can be decoded and displayed, when decoding starts from I-picture. Also, the degree of allowance for the reference structure has been limited since the memory can store, at maximum, two reference pictures.

[0028]

FIG. 25 is a conceptual diagram showing the conventional image coding method defined in the JVT. According to the JVT, it is possible to refer to an arbitrary distant picture as long as it does not go across the special IDR picture. Therefore, it is possible, for example, to code many pictures by rearranging the coding order with the view to enhance the coding efficiency. In the diagram, the correlativity among the pictures 19, 20, 21, 25, 26 and 27 is very strong as well as among the pictures 22, 23, 24, 28, 29 and 30. In this case, the coding efficiency can be improved by inter-picture coding firstly the pictures 19, 20, 21, 25, 26 and 27 (GOP1) and then the pictures 22, 23, 24, 28, 29 and 30 (GOP2).

[0029]

FIG. 26 is a flowchart showing the operation performed in the conventional coding method defined in the JVT. According to the

coding method defined in the JVT, all the uncoded pictures can be the candidate pictures for coding (Step S55). Then, a picture is selected from the candidate pictures for coding based on certain criteria (Step S56). For example, when the number of uncoded pictures is ten, all the ten pictures may be determined as candidate pictures for coding and the tenth picture in display order may be selected for coding. After the coding, when an uncoded picture is still found, the procedure returns to Step S55. In Step 56, another uncoded picture may be awaited for input instead of coding processing.

[Problems that Invention is to Solve]

[0030]

Meanwhile, the conventional image decoding apparatus and the image decoding apparatus as such have been unable to edit a coded stream except for IDR pictures, that is, special intra pictures. The following describes this problem.

[0031]

FIG. 19 is a conceptual diagram for explaining the problem that the non-sequentiality in the sequence generates a non-sequentiality in the display order information POC and thereby removes a picture which is not displayed yet. The diagram shows the case in which a sequence is decoded after having combined the two parts, Clip1 and Clip2. A place where the non-sequentiality in the sequence generated by such editing or for other reasons is called an editing point. In this example, the maximum value of the display order information POC is set so that the circulation of the values indicated by the display order information POC does not need to be considered. (A) in the diagram shows a state of the memory after the Clip1 is decoded and the memory stores the pictures I19, P22, B20 and B21. Each POC is as shown in the diagram while it is assumed that the pictures I19, B20, and B21 are marked as "unused". Next, (B) in the diagram shows a state of the memory after the first picture I85 in the Clip2 is decoded, but before the second picture P86 is decoded. Here, it is assumed that the picture I85 is stored in the position where the picture B20 has been stored.

[0032]

Subsequently, it is assumed that the picture I85 in the Clip2 is marked as "unused" in the unused marking processing (see (B) in the diagram). Then, in the following processing of allocating a free space, the picture I85 is removed since the picture located in the earliest position in display order is to be removed out of the pictures marked "unused". Here, assuming that an average number of pictures which are delayed for the display after the decoding is three, the pictures B21, P22, and I85 are not displayed yet. However, the picture I85 is removed despite the fact that it is not displayed yet.

[0033]

FIG. 23 is a conceptual diagram for explaining a problem that the non-sequentiality in the sequence generates a non-sequentiality in the frame number FN and that a dummy picture removes the picture which is not displayed yet. The example shows how a sequence is decoded after having combined non-sequential parts Clip1 and Clip2. (A) in the diagram shows a state of the memory after the picture P25 is decoded and five pictures of the picture P21 through the picture P25 are stored. (B) in the diagram shows a state of the memory after the dummy picture is inserted when the first picture I60 in the Clip2 is decoded. The picture I60 has an FN indicating "12" while the picture P25, which is decoded immediately before the picture I60, has an FN indicating "5". It is therefore determined that six pictures are lost, and six dummy pictures are inserted. In this case, all the pictures stored in the memory are removed, causing a problem that, for instance, in the state as shown in (A) of the diagram, the pictures P23, P24 and P25 are removed although they are not displayed yet.

[0034]

FIG. 27 is a conceptual diagram for explaining a problem caused by the degree of allowance in the coding defined by the JVT at the time of editing or performing access random processing. (B) in the diagram is an original stream that is the same as the stream shown in FIG. 25. (A) in the diagram shows how the GOP2 is decoded without the GOP1. In this case, the pictures 25 through 27 cannot be replayed after replaying the pictures 22 through 24 since the pictures

25 through 27 have not been obtained, which causes non-sequentiality in replay. This problem occurs when the GOP1 is removed as a result of editing or when performing random access starting from the GOP2, or in other cases. (C) in the diagram shows how the GOP1 is decoded without the GOP2. In this case, the non-sequentiality in replay is generated because the pictures 22 through 24 have not been obtained. This problem occurs when the GOP2 is removed as a result of editing.

[Means to Solve the Problems]

[0035]

To solve this problem, a first invention is an image coding method for coding an image signal on a picture-by-picture basis, and the image coding method includes outputting flag information A, when values indicated by display order information of a picture and display order information of a picture immediately before the picture are non-sequential, to a point immediately before the picture, the flag information A indicating that the values indicated by the display order information are non-sequential.

[0036]

A second invention is an image decoding method for decoding an image signal that is coded on a picture-by-picture basis, and the image decoding method includes managing a display order of each picture such that the display order of the picture immediately before the flag information in decoding order precedes a picture after the flag information A in the decoding order, when the flag information A indicates non-sequentiality of the display order.

[0037]

A third invention is an image coding method for coding an image signal on a picture-by-picture basis, and the image coding method includes outputting flag information B, when an image coding signal is output which instructs to compensate non-sequentiality of referenced picture numbers by inserting a specific picture having no actual decoded image, and when the referenced picture number of a certain picture and the referenced picture number of the picture

immediately before the certain picture are non-sequential, the flag information B instructing not to perform the compensation.

[0038]

A fourth invention is an image decoding method for decoding an image signal that is coded on a picture-by-picture basis, and the image decoding method includes not inserting a specific picture having no actual image, when flag information B indicates non-sequentiality of referenced picture numbers.

[0039]

A fifth invention is an image coding method for coding an image signal on a picture-by-picture basis, and the image coding method includes coding, on a basis of the pictures collected to be sequential in display order, such that a display order of a given picture in a unit precedes a display order of a given picture in a unit immediately after the unit in the order of coding the unit.

[0040]

A sixth invention is an image coding method for coding an image signal on a picture-by-picture basis, and the image coding method includes assigning information indicating a position of a first picture independently decodable in the unit into a random access unit, on a basis of the random access unit into which the pictures are collected.

According to the present invention configured as above, it is possible to solve the problem of removing the pictures that are not displayed, which is caused by non-sequentiality in POC and FN as a result of editing.

[Embodiments of the Present Invention]

[0041]

Hereinafter, embodiments of the present invention will be described.

[First Embodiment]

FIG. 1 is a diagram showing the concept used in the image coding method and the image decoding method according to the present invention. The diagram shows how to solve the existing

problem shown in FIG. 19. Firstly, the non-sequentiality in the display order information POC caused by editing or for other reasons is detected by a flag inserted at the time of coding. This flag is called a flag A. The flag A is a flag indicating that the values indicated by the display order information POC are non-sequential because of editing or for other reasons.

[0042]

As shown in the diagram, the flag A is special information to be placed immediately before Clip. Here, the flag A is assumed to be stored in a unit for storing additional information on video decoding called Supplemental Enhancement Information (to be referred to as "SEI" hereinafter) as defined by the JVT. The flag A, however, may be stored in a User Data Registered SEI which allows the user to define the unit on its own or in a Random Access Point SEI (to be referred to as RAP SEI hereinafter) for storing information on random access.

[0043]

The following information is stored in the RAP SEI: "broken_link_flag" indicating that the decoded image may be different from the original image due to editing, or other reasons; and "recovery_frame_cnt" indicating the "n" number, when the image, in which the pictures following the "n" th picture in display order being based on the position of the RAP SEI are decoded, is same or almost same as the original image. In the present invention, when "broken_link_flag" indicates "1", it shows that the editing is carried out and regards either of the following as an editing point: a position immediately before the first picture following the RAP SEI; a position immediately before the picture indicated in the "recovery_frame_cnt"; and the first picture that can be decoded independently (e.g., Intra Picture) following "RAP_SEI".

[0044]

It should be noted that the editing point indicates only the boundary between the pictures and not the boundary between the SEIs. A file format storing a sequence may store random access information for each of the pictures, and in some cases, such information may store the information indicating that the editing is

carried out, and furthermore, the information on the editing point as well. In this case, a detection of the editing and an identification of the editing point are operated according to the information on the file format. Such storing format is called “flag A”.

[0045]

When the editing point is identified, the processing regarding the display order is performed such that the display orders of all the pictures before the editing point precede the display orders of all the pictures after the editing point. That is to say, when selecting a picture to be removed from among the pictures marked as “unused”, it is assumed that the display order of the picture located before the editing point precedes that of the picture located after the editing point.

[0046]

To manage the display order, each of the pictures may hold a Clip counter, which increases by 1 each time the processing shifts to the picture located after the editing point. As shown in (B) in the diagram, “Clip=1” is recorded for the pictures B20, P22, B21 while “Clip=2” is recorded for the picture I85 located after the editing point. In the unused marking processing at this state, the picture B20 having the earliest display time is removed out of the “unused” pictures with the Clip that is firstly decoded (the pictures B20, P22 and B21 marked as “Clip=1”). In this way, the problem of removing the picture which is not displayed yet (the picture I85 in this case) can be solved.

[0047]

FIG. 2 is a block diagram showing the structure of the image decoding apparatus according to the present embodiment. The difference between the present image decoding apparatus and the conventional decoding apparatus (FIG. 16) is that the former includes an editing detection unit EditDet and the memory management unit MemCtrlA is modified from the memory management unit MemCtrl. The editing detection unit EditDet obtains, from the variable length decoding unit VLD, either information indicating that the editing has been carried out or information including the editing point information, analyzes the obtained information, and outputs a control signal mctrlc

to the memory management unit MemCtrlA. When receiving the control signal indicating that the editing has been carried out, the memory management unit MemCtrlA manages in such a manner that the picture located before the editing point precedes the picture after the editing point in display order.

[0048]

FIG. 3 is a flowchart showing the operation performed in the image decoding method according to the present embodiment. In the present image decoding method, Steps S31 and S32 are added and Step S14 is modified to Step S14B, which is different from the conventional decoding method (FIG. 17). After starting the processing on a picture-by-picture basis (Step S1), whether or not the image is edited is examined (Step S31). When the editing is detected, processing at the editing point is operated (Step S32). When the editing is not detected, the unused marking processing is performed as in the conventional case (Step S13) and the processing of allocating a free space in consideration of the decoding order in the vicinity of the editing point is operated (Step S14B). The "processing at the editing point" is operated in order to identify the editing point. The memory management unit 205 increases the Clip counter by 1 each time the processing is shifted to the picture which is located after the editing point.

[0049]

FIG. 4 is a flowchart showing the operation of allocating a free space performed in the image decoding method according to the present embodiment. In the present decoding method, Step S43 is modified to S43B, which is different from the conventional method (FIG. 17). When "unused" pictures are stored in the memory (Step S41), the Clip including the "unused" pictures is searched in prioritizing the Clip which is located earlier in decoding order, and the picture located in the earliest position in display order among the "unused" pictures in the Clip is removed. In other words, the picture located in the earliest position in display order among the "unused" pictures in the Clip including the first "unused" picture in decoding order, is removed. That is to say, the picture located in the earliest

position in display order among the "unused" pictures located between the editing points immediately before and after the "unused" picture in the earliest position in decoding order, is removed.

[0050]

The information indicating the editing point is necessary for solving the non-sequentiality caused by editing with the use of such image decoding method according to the present invention (FIGS. 1, 2, 3 and 4). Therefore, it is desirable that the information indicating the inclusion of the editing point information (referred to as flag A2 here) is located in the place to which the decoding apparatus can easily access.

[0051]

According to the image decoding method according to the present invention, the flag A2 may be stored in a sequence parameter set or in the User Data Registered SEI which allows the user to define a unit on its own so that the information is arranged in a place in the sequence to which the user can access easily, for instance, at the head of the sequence, or may be stored in a medium which records the sequence or in a file format which manages the sequence. Such storing format is called "flag A2".

[0052]

In this case, when obtaining a flag A2 from such place and thereby the editing point information, the editing detection unit 203 performs the image decoding method according to the present invention (FIGS. 1, 2, 3 and 4) at the time of decoding.

[0053]

[Second Embodiment]

FIG. 5 is a block diagram showing the structure of the image decoding apparatus according to the present embodiment. The diagram shows that an editing detection unit EditDet is added and a modification is made for the memory management unit MemCtrlC, respectively to the conventional decoding apparatus described in FIG. 21. The editing detection unit EditDet is the same as the first embodiment. The memory management unit MemCtrlC does not insert the dummy pictures when the editing detection unit EditDet

informs that editing is detected.

[0054]

FIG. 6 is a flowchart showing the operation performed in the decoding method according to the present invention. The diagram shows that Step S31 is added and a modification is made concerning Step S14B in the flowchart shown in FIG. 22 in the case of employing the conventional decoding apparatus. Other steps are carried out in the same manner as the steps having the same referential marks shown in FIG. 22, and the description is omitted here. The Steps S31 and S14B are the same as the Steps S31 and S14B executed by the decoding apparatus according to the first embodiment of the present invention, so that the description is omitted here.

[0055]

The coding apparatus according to the present invention, when inserting a dummy picture, the flag B indicating that the frame numbers FN are non-sequential is inserted between the pictures where the non-sequentiality in the frame number FN occurs. Alternatively, the flag B may instruct not to insert the dummy picture although there is a possibility of occurrence of non-sequentiality in the frame number FN by editing point and so on. The flag information B may be inserted in the same manner as the flag A in the first embodiment.

[0056]

As in the first embodiment, the coding apparatus according to the present invention generates flag information B2 indicating that the flag B is generated. The storing format of flag B2 is the same as the storing format of flag A2 as shown in the first embodiment.

[0057]

As in the first embodiment, the decoding apparatus according to the present invention obtains flag B2, and when the flag B is obtained, the processing according to the picture decoding method in the present invention (FIGS. 5 and 6) is performed.

[Third Embodiment]

FIG. 7 is a diagram showing the structure of the data outputted based on the image coding method according to the present invention

and that of the data inputted based on the image decoding method according to the present invention, both of which data structures are described in the first and second embodiments. A sequence, which is a coded image signal, includes data such as "RAP", "MMCO" and "PICTURE" as shown in (A) in the diagram. The "RAP" presents Random Access Point SEI including "broken_link_field", the flag A mentioned in the first embodiment, which is also the flag B mentioned in the second embodiment. The "PICTURE" is an image signal which is coded on a picture basis and, in some cases, the "MMCO" is located before the "PICTURE" (but is not located in other cases). The "MMCO" is instruction information used in a memory management control operation. As shown in (B) in the diagram, the flag A2 mentioned in the first embodiment, which is also the flag B2 mentioned in the second embodiment, is stored in either of the following places: in the sequence, in a predetermined position of the file format associated with the sequence, and on a recording medium for recording the sequence, or in other places.

[0058]

[Fourth Embodiment]

FIG. 8 is a diagram showing the concept used in the image coding method according to the present embodiment. The present image coding method, which solves the problem described in FIG. 27, stores only the pictures which are sequential in display order in a certain GOP and code the pictures in such a manner that the location in display order of arbitrary pictures included in said GOP comes before that of arbitrary pictures included in the GOP to be decoded next. By thus coding, non-sequentiality in replay is neither generated in the GOP1 nor in the GOP2 in the case shown in FIG. 27.

[0059]

FIG. 9 is a flowchart showing the operation performed in the image coding method according to the present embodiment. The processing is explained with reference to (A) in the diagram. A group of consecutive pictures starting from a picture located in the earliest position in display order among the uncoded pictures is determined as a basic display unit (Step S61). That is to say, a unit is defined as a

group of more than one picture in which the pictures are sequentially arranged in display order so as not to generate the picture that is to be displayed before the basic display unit but is still not displayed.

[0060]

Then, whether or not an uncoded picture is found in the basic display unit is examined (Step S62). When an uncoded picture is found in the basic display unit, the picture is determined as a candidate picture for coding and a picture selected from plural candidate pictures for coding is coded (Step S63). Whether or not an uncoded picture is still found is examined (Step S64), and when it is found, the processing proceeds to Step S62, but terminates when it is not found. It should be noted that the basic display unit can be modified with arbitrary timing as long as the following condition is satisfied: "the basic display unit includes at least the consecutive pictures starting from the picture located in the earliest position in display order among the uncoded pictures and ending at the picture located in the last position in display order among the coded pictures".

[0061]

In addition, (B) shown in the diagram is a flowchart showing the operation performed in the image coding method according to the present embodiment. According to this method, the consecutive pictures starting from the picture located in the earliest position in display order among the uncoded pictures and ending at the picture located in the last position in display order among the coded pictures are regarded as imperative candidate pictures for coding (Step S71). Then, a picture is selected from the uncoded pictures including the imperative candidate pictures for coding, and is coded (Step S72). Next, whether or not an uncoded picture is found is examined (Step S73). When it is found, the processing proceeds to Step S71, but the processing terminates when it is not found.

[0062]

[Fifth Embodiment]

FIG. 10 is a diagram showing the concept used in the image coding method according to the present invention. The fourth embodiment has shown the method to simultaneously solve the

problems occurring at the time of editing as well as performing random access processing. The present image coding method is a method for solving the problem occurring when performing random access. The present method, having fewer restrictions than the method described in the fourth embodiment, can improve coding efficiency. In the present image coding method, the following restrictions are defined, using GOP2 in the figure as an example:

(1) pictures (B26, B27 and P28) with the display time later than that of the intra-picture (I25) within a certain GOP are not coded in the GOP (GOP1) which immediately precedes the GOP including the intra-picture (GOP2). By thus controlling the coding, even when the decoding starts from the first picture (I25) included in the GOP2, all the pictures following the first picture (I25) can be displayed properly, as shown in Case A in the diagram;

[0063]

(2) Furthermore, pictures (I19, B20, B21, B22, B23 and P24) with the display time earlier than that of the intra-picture (I25) in a certain GOP and also later than that of the intra-picture (I19) included in the GOP which immediately precedes the GOP are coded in the GOP (GOP2) or in the GOP immediately preceding said GOP (GOP1). By thus controlling the coding, even when the decoding starts from the first picture (I19) in the GOP1, all the pictures following the first picture (I19) included in the GOP1 can be displayed properly, as shown in Case B in the diagram.

[0064]

In other words, (1) taking the GOP1 as an example, the picture to be displayed earlier than the I-picture (I25) in the following GOP is selected as the last picture to be displayed within a certain GOP, and then is coded (namely, the picture preceding the picture P24 including the picture P24 should be selected). (2) taking the GOP2 as an example, the first picture to be displayed within a certain GOP is selected from among the pictures to be displayed later than the I-picture (I19) in the immediately preceding GOP, and then is coded (namely, the picture following the picture B20 including the picture B20 should be selected).

[0065]

In other words, in the present image coding method, the display order of the picture to be firstly displayed in a certain GOP is later than that of the I-picture included in the immediately preceding GOP, and the display order of the picture to be lastly displayed included in the GOP is earlier than that of the I-picture included in the immediately following GOP. It should be noted that the I-picture has been described as an example here, but the same applies to the picture that can be decoded independently.

[0066]

FIG. 11 is a flowchart showing the operation performed in the image coding method according to the present embodiment. Firstly, an uncoded picture is selected and then coded as an entry picture (Step S81). The entry picture is a picture that can be decoded independently. Then, the uncoded picture which is earlier in display order than that of the lastly-coded entry picture is determined as an imperative candidate picture for coding while the uncoded picture which is earlier in display order than that of the entry picture to be subsequently coded is determined as an omittable candidate picture for coding (Step S82).

[0067]

Then, whether or not an uncoded picture is found among the imperative candidate pictures for coding is examined (Step S83). When it is found, a picture is selected from among the imperative candidate pictures for coding and the omittable candidate pictures for coding, and then the picture is coded (Step S85). Then, whether or not an uncoded picture is found among the candidate pictures for coding is examined again (Step S86). When it is found, the processing proceeds to Step S83, but when it is not found, the processing terminates. When an uncoded picture is not found in the imperative candidate pictures for coding, whether or not to code the next entry picture is determined in Step S84. When the entry picture is coded, the processing proceeds to Step S81, and the processing proceeds to Step S85 when the entry picture is not coded.

[0068]

[Sixth Embodiment]

Furthermore, the processing shown in each of the above embodiments can be carried out easily in an independent computer system by recording a program for realizing the image coding/decoding methods described in each of the above embodiments onto a recording medium such as a flexible disk or the like.

[0069]

FIG. 12 is an illustration diagram of the case where the image coding or decoding method described in each of in the above embodiments is executed by a computer system, using the flexible disk on which such methods are recorded.

[0070]

FIG. 12(b) shows an external front view, a cross-sectional structure of a flexible disk, and the flexible disk itself, and FIG. 12(a) shows an example of a physical format of the flexible disk as a main body of a recording medium. A flexible disk FD is contained in a case F with a plurality of tracks Tr concentrically formed from an outer circumference to an inner circumference of the disk, and each track is divided into 16 sectors Se in an angular direction. Thus, the image coding method and the image decoding method as the program are recorded in an assigned area on the flexible disk FD.

[0071]

In addition, FIG. 12(c) shows a configuration for recording and reproducing the program on the flexible disk FD. When the program is recorded on the flexible disk FD, the computer system Cs writes the image coding and decoding methods as the program via a flexible disk drive FDD. In addition, when the image coding and decoding methods are constructed in the computer system using the program on the flexible disk, the program is read out from the flexible disk and then transferred to the computer system by the flexible disk drive FDD.

[0072]

Note that the above description has been provided using a flexible disc as a recording medium, but the same processing can also

be performed using an optical disk. In addition, the recording medium is not limited to such a flexible disk or optical disk, but any other medium such as an IC card and a ROM cassette capable of recording a program can be used.

[Effects of the Invention]

[0073]

As is clear from the above description, it is possible to edit an image at any place, not necessarily at the IDR picture which is a special intra picture.

[Brief Description of Drawings]

[FIG. 1] FIG. 1 is a diagram showing the concept of the image decoding method according to the present invention (first embodiment).

[FIG. 2] FIG. 2 is a block diagram showing the image decoding apparatus according to the present invention (first embodiment).

[FIG. 3] FIG. 3 is a flowchart showing the operation performed in the image decoding method according to the present invention (first embodiment).

[FIG. 4] FIG. 4 is a flowchart showing the operation of allocating a free space in the memory performed by the image decoding apparatus according to the present invention (first embodiment).

[FIG. 5] FIG. 5 is a block diagram showing the image decoding device according to the present invention (second embodiment).

[FIG. 6] FIG. 6 is a flowchart showing the operation performed in the image decoding method according to the present invention (second embodiment).

[FIG. 7] FIG. 7 is a diagram showing the structure of the data outputted by the image coding method according to the present invention and the structure of the data inputted by the picture decoding method according to the present invention (third embodiment).

[FIG. 8] FIG. 8 is a diagram showing the concept used in the

image coding method according to the present invention (fourth embodiment).

[FIG. 9] FIG. 9 is a flowchart showing the operation performed in the image coding method according to the present invention (fourth embodiment).

[FIG. 10] FIG. 10 is a diagram showing the concept used in the image coding method according to the present invention (fifth embodiment).

[FIG. 11] FIG. 11 is a flowchart showing the operation performed in the image coding method according to the present invention (fifth embodiment).

[FIG. 12] FIG. 12 are illustrations of a recording medium for recording a program for realizing the image coding method and the picture decoding method according to each of the above embodiments of the present invention in a computer system (sixth embodiment).

[FIG. 13] FIG. 13 is a diagram showing the concepts of a display order (POC) and a reference picture number.

[FIG. 14] FIG. 14 is a diagram showing the operation of removing a picture in order to allocate a free space in a memory, when the memory has a picture marked as "unused".

[FIG. 15] FIG. 15 is a diagram showing the operation of removing a picture in order to allocate a free space in a memory, when the memory does not have a picture marked as "unused".

[FIG. 16] FIG. 16 is a block diagram showing the structure of the conventional image decoding apparatus.

[FIG. 17] FIG. 17 is a flowchart showing the memory-related operation performed by the conventional image decoding apparatus.

[FIG. 18] FIG. 18 is a flowchart showing the operation for allocating a free space performed by the conventional image decoding apparatus.

[FIG. 19] FIG. 19 is a conceptual diagram explaining the problem that a non-sequentiality in the sequence generates a non-seqentiality in the display order information POC and thereby removes a picture that is not yet displayed.

[FIG. 20] FIG. 20 is a conceptual diagram showing the

operation for dummy pictures.

[FIG. 21] FIG. 21 is a block diagram showing the structure of the conventional image decoding apparatus.

[FIG. 22] FIG. 22 is a flowchart showing the operation for dummy pictures performed by the conventional image decoding apparatus.

[FIG. 23] FIG. 23 is a conceptual diagram showing the problem that the non-sequentiality in the sequence generates a non-sequentiality in the frame number FN and that the dummy picture removes the picture which is not displayed yet.

[FIG. 24] FIG. 24 is a conceptual diagram showing the conventional structure of the stream according to MPEG-2.

[FIG. 25] FIG. 25 is a conceptual diagram showing the conventional image coding method according to the JVT.

[FIG. 26] FIG. 26 is a flowchart showing the conventional image coding method according to the JVT.

[FIG. 27] FIG. 27 is a conceptual diagram showing the problem caused by the degree of allowance in the coding defined by the JVT at the time of editing or performing random access.

[Numerical References]

VLD Variable length decoding unit

PicDec Picture decoding unit

Mem Memory

MemCtrl, MemCtrlA, MemCtrlB, MemCtrlC Memory management unit

POC Picture order count

FN Frame number (referenced picture order information)

EditDet Editing detection unit

MMCODec MMCO decoding unit

FNGapDet FN gap detection unit

Cs Computer system

FD Flexible disk

FDD Flexible disk drive

[Document] Abstract of the Disclosure

[Abstract]

[Object]

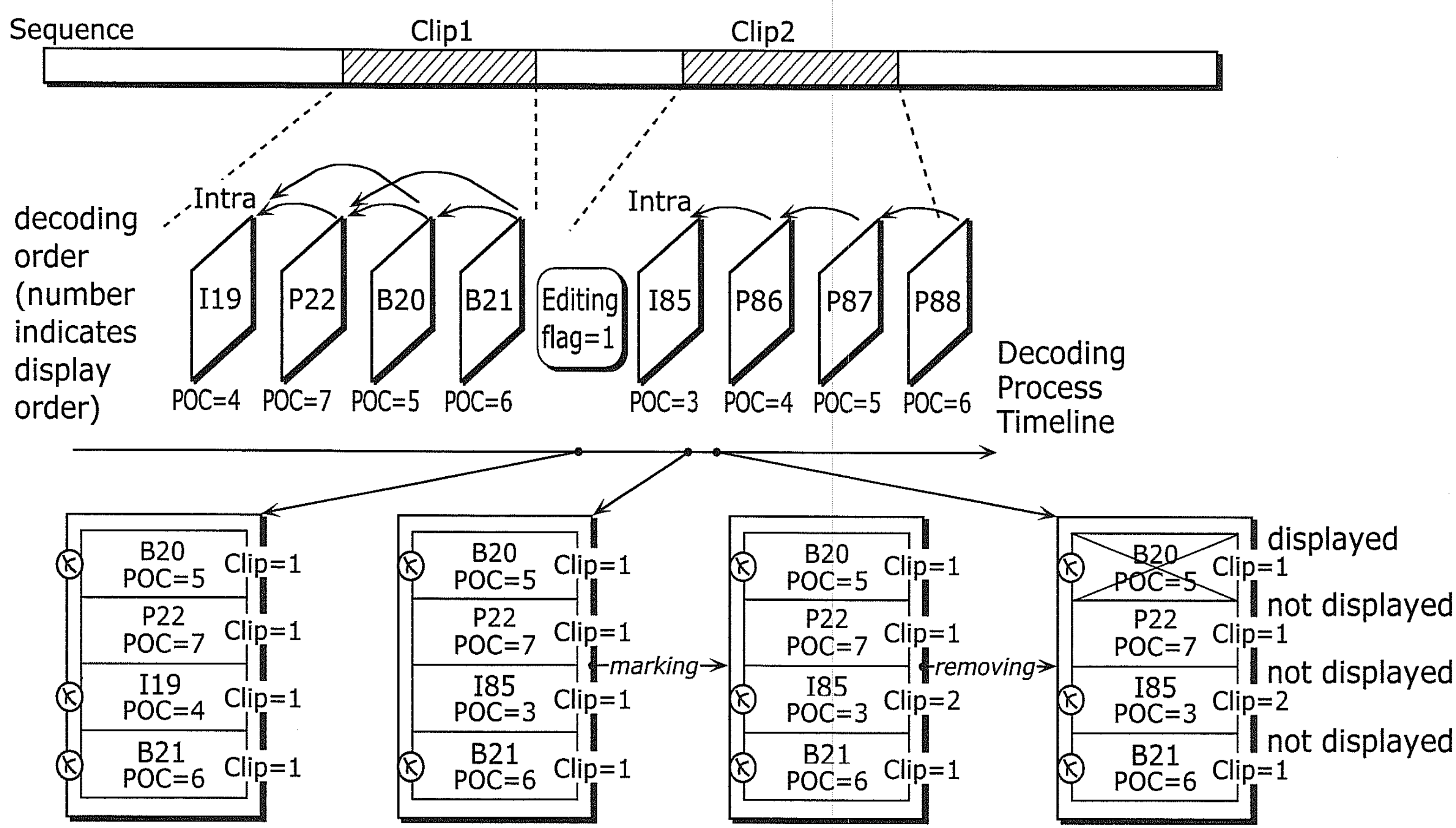
According to JVT, it is not possible to perform editing in other than an IRD picture that is a special intra picture. This is because editing causes non-sequentiality of the display order information (POC) or referenced picture order information (FN), and causes a problem that a picture that is not yet displayed is removed.

[Means to Achieve the Object]

An image coding method of assigning a flag indicating non-sequentiality in POC generated by editing and a flag which inhibits insertion of a dummy picture, an image coding method of ignoring the non-sequentiality of POC based on the flags, and an image decoding method of not inserting the dummy picture based on the flag.

[Selected Drawing]FIG. 1

FIG. 1



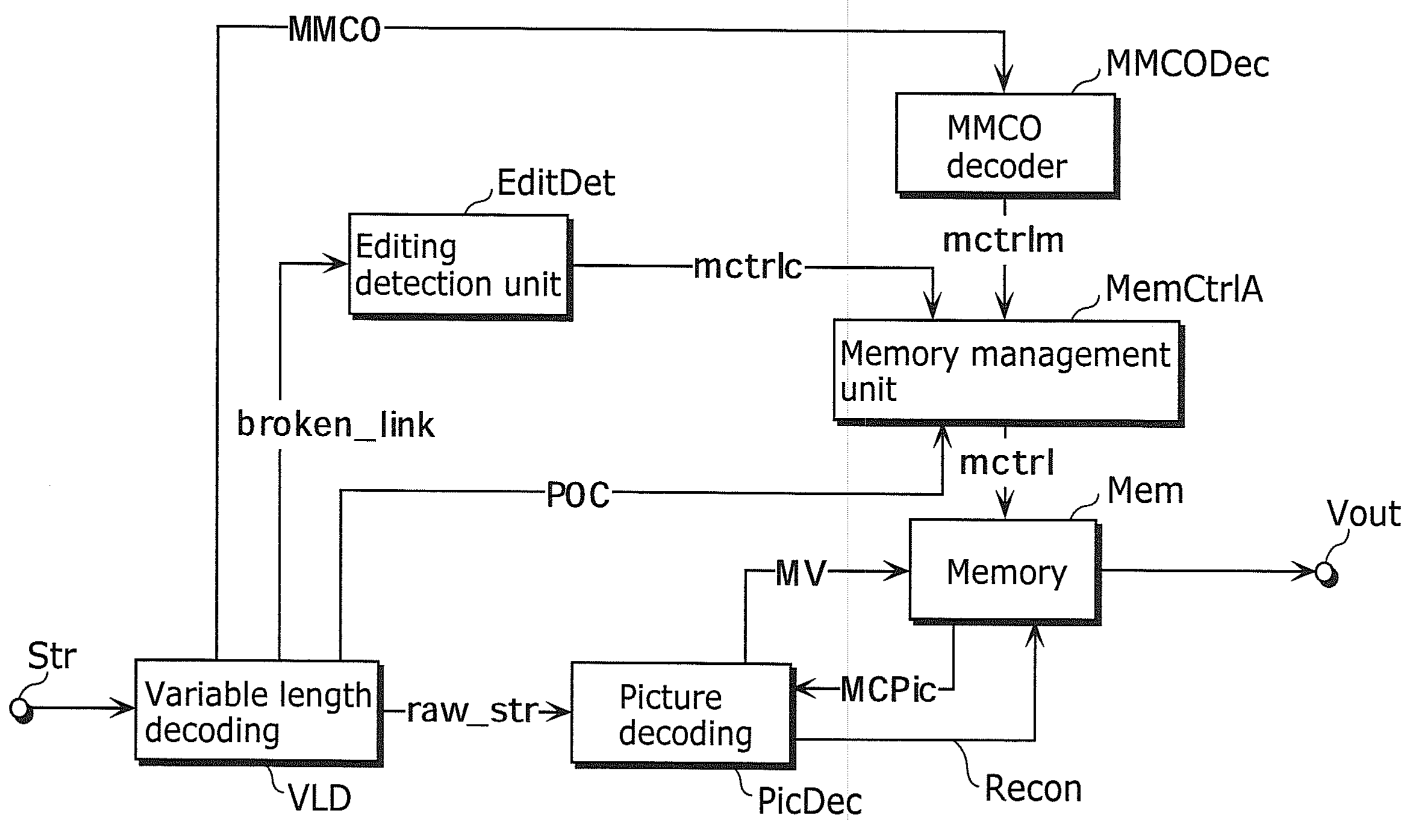
(A) I85 (stage 1)

(B) P86 (stage 1)

(B) P86 (stage 2); I85 was marked as "unused"

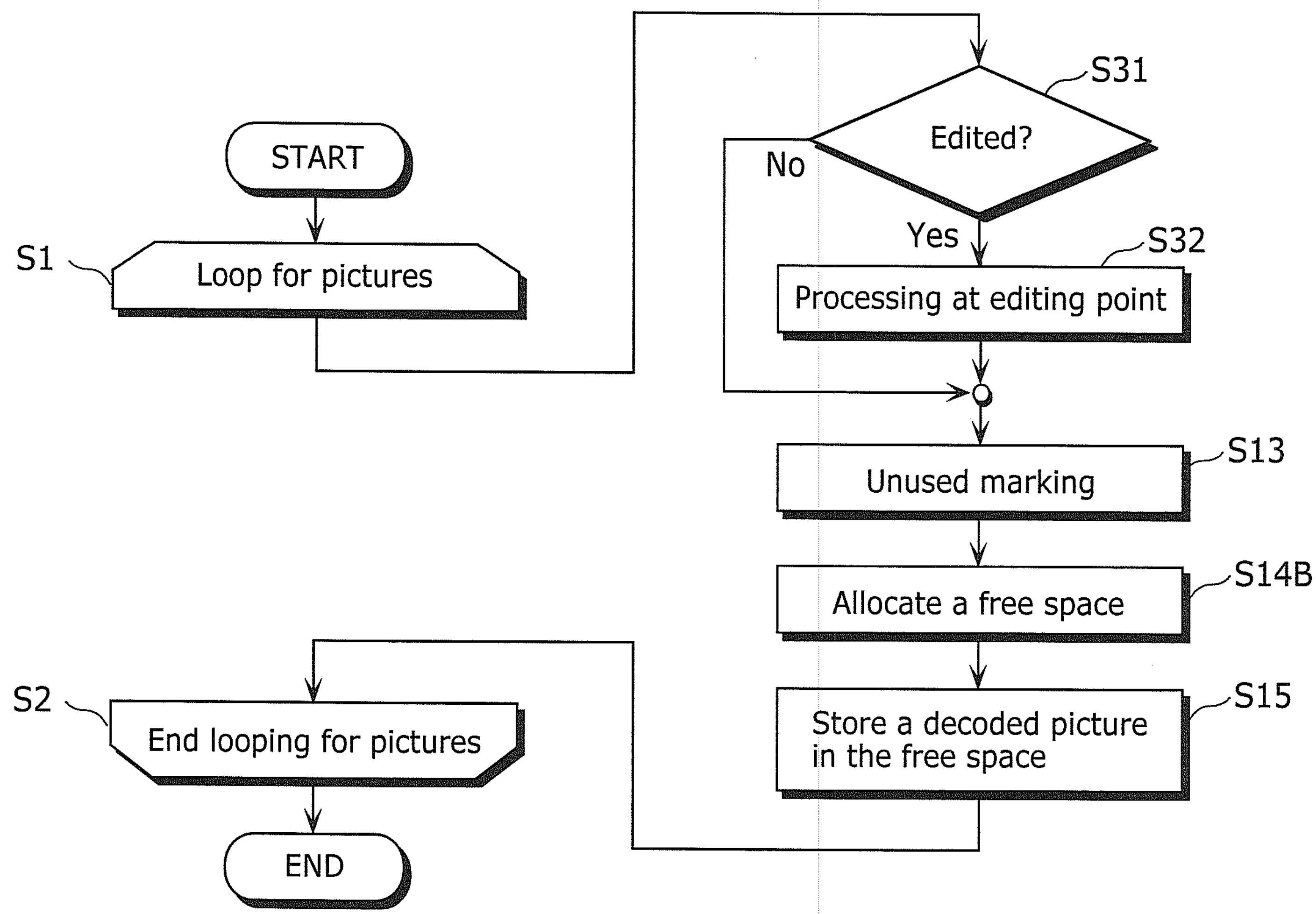
(C) P86 (stage 3); first-display picture in unused picture in first-decoded clip was removed

FIG. 2



MMCO
MMCODec
MMCO decoder
EditDet
Editing detection unit
mctrlc
mctrlm
MemCtrlA
Memory management unit
broken_link
POC
mctrl
Mem
Vout
MV
Memory
Str
Variable length decoding
raw_str
Picture decoding
MCPic
VLD
PicDec
Recon

FIG. 3



START
S1
Loop for pictures
S31
Edited?
No
Yes
S32
Processing at editing point
S13
Unused marking
S14B
Allocate a free space
S15
Store a decoded picture
in the free space
S2
End looping for pictures
END

FIG. 4

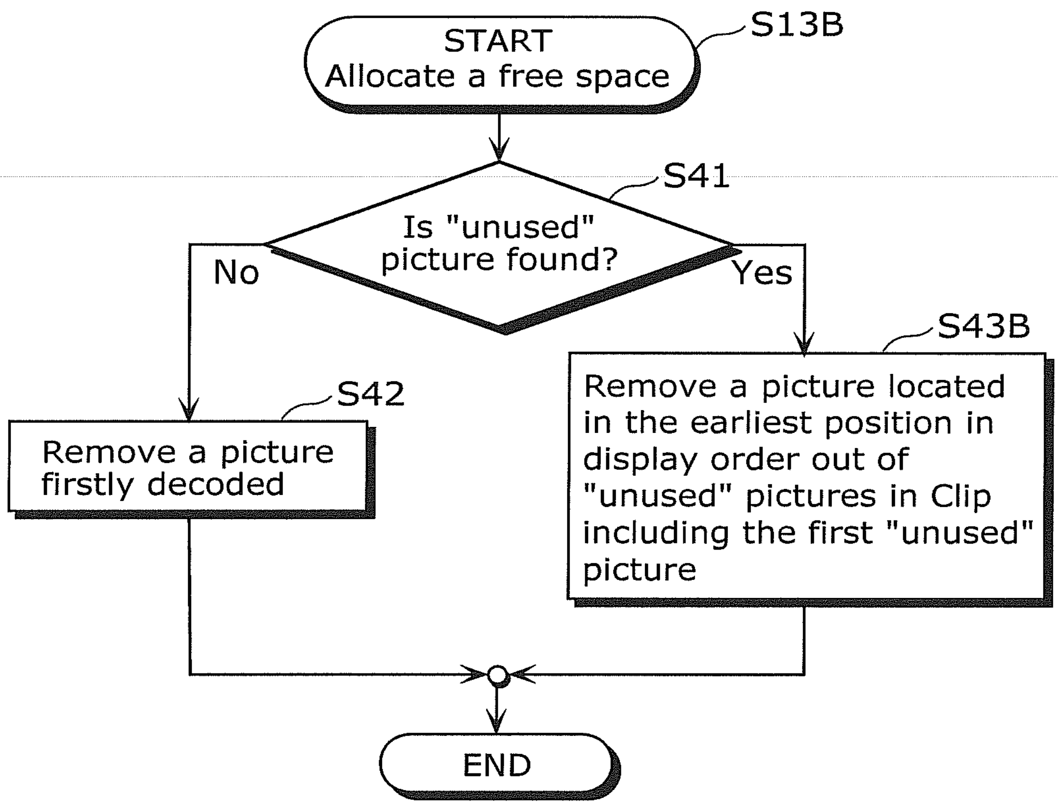
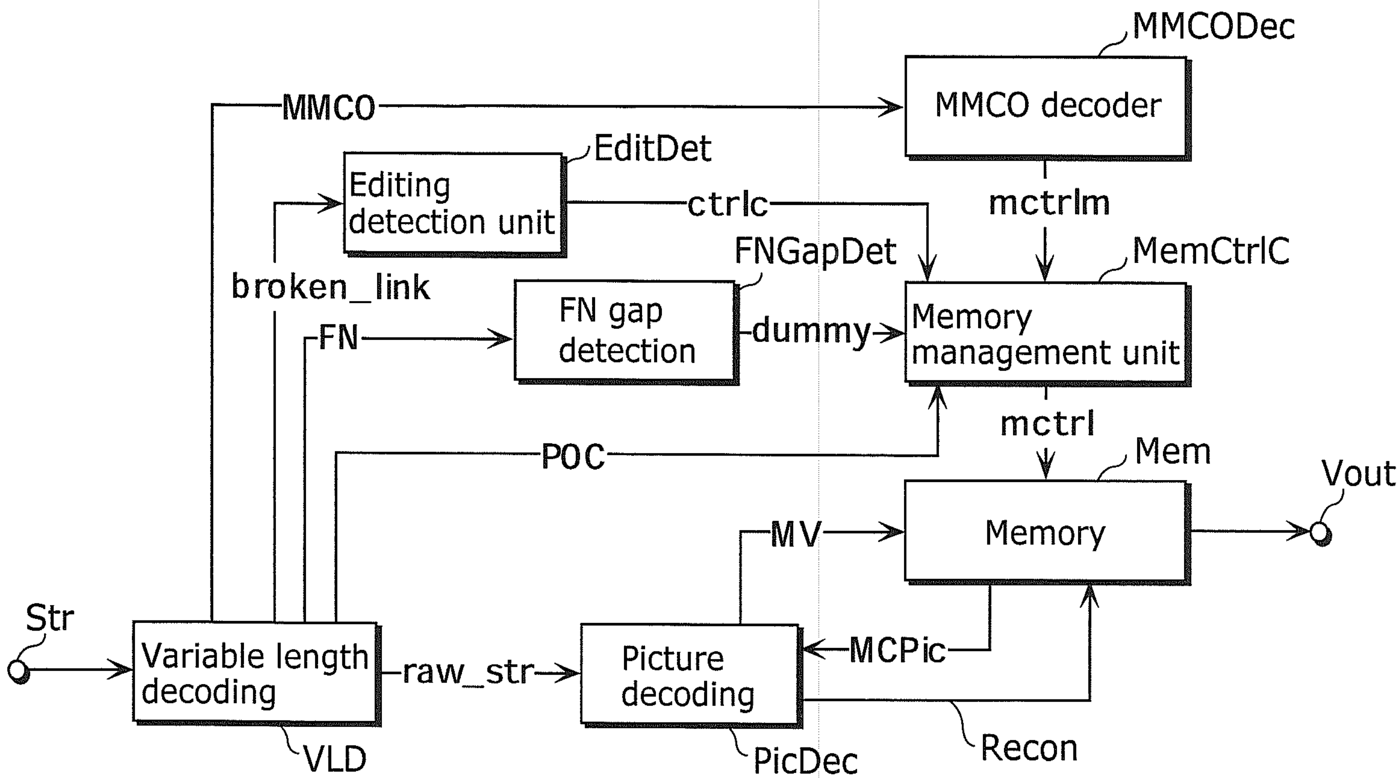
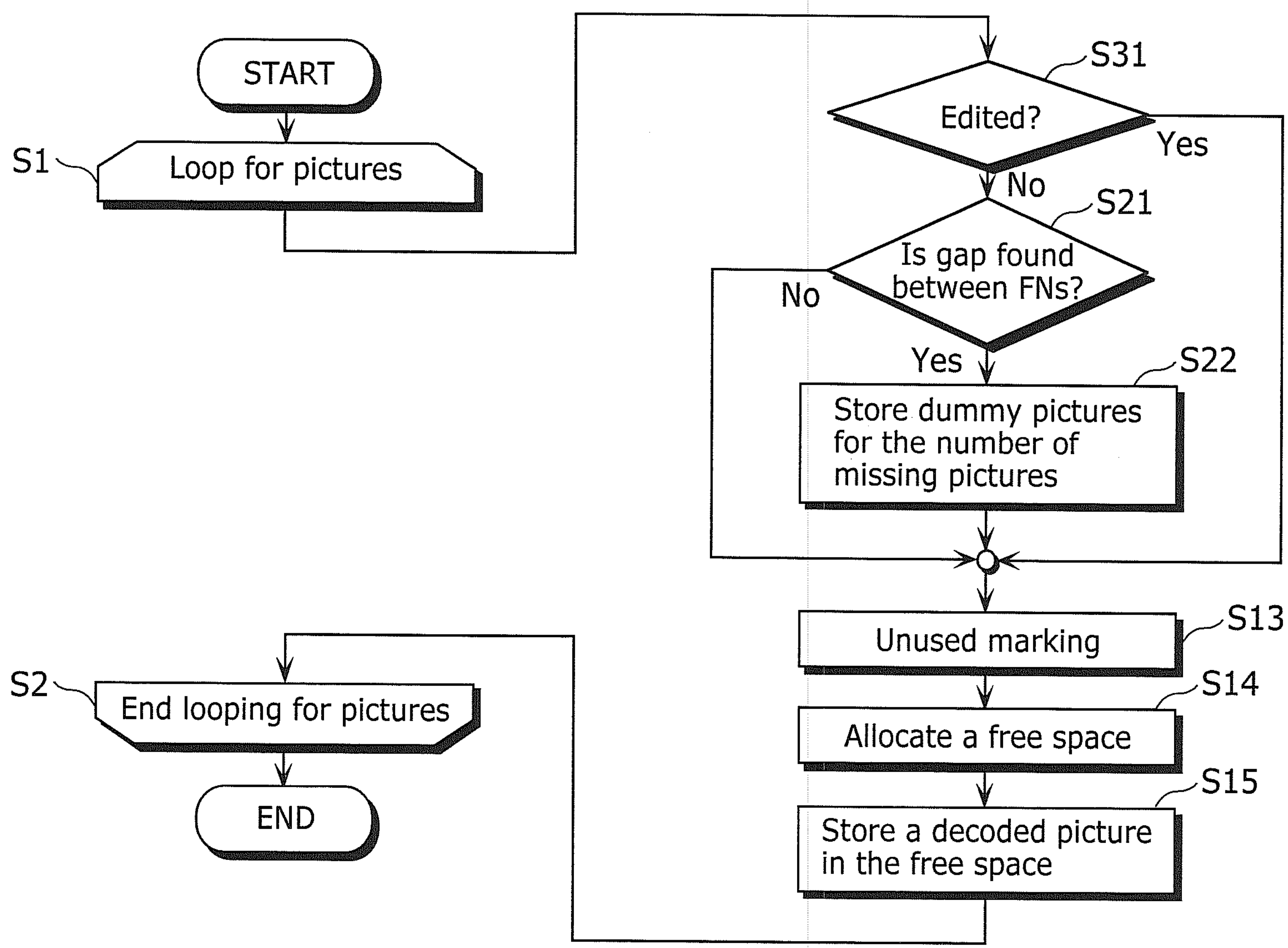

START
Allocate a free space
S13B
S41
Is "unused" picture found?
No
Yes
S42
Remove a picture firstly decoded
S43B
Remove a picture located in the earliest position in display order out of "unused" pictures in Clip including the first "unused" picture
END

FIG. 5



MMCODec
MMCO decoder
MMCO
EditDet
Editing detection unit
ctrlc
mctrlm
FNGapDet
MemCtrlC
broken_link
FN gap detection
dummy
Memory management unit
FN
mctrl
POC
Mem
Vout
MV
Memory
Str
Variable length decoding
raw_str
Picture decoding
MCPic
VLD
PicDec
Recon

FIG. 6



START
S1
Loop for pictures
S31
Edited?
Yes
No
S21
Is gap found between FNs?
No
Yes
S22
Store dummy pictures for the number of missing pictures
S13
Unused marking
S14
Allocate a free space
S15
Store a decoded picture in the free space
S2
End looping for pictures
END

FIG. 7

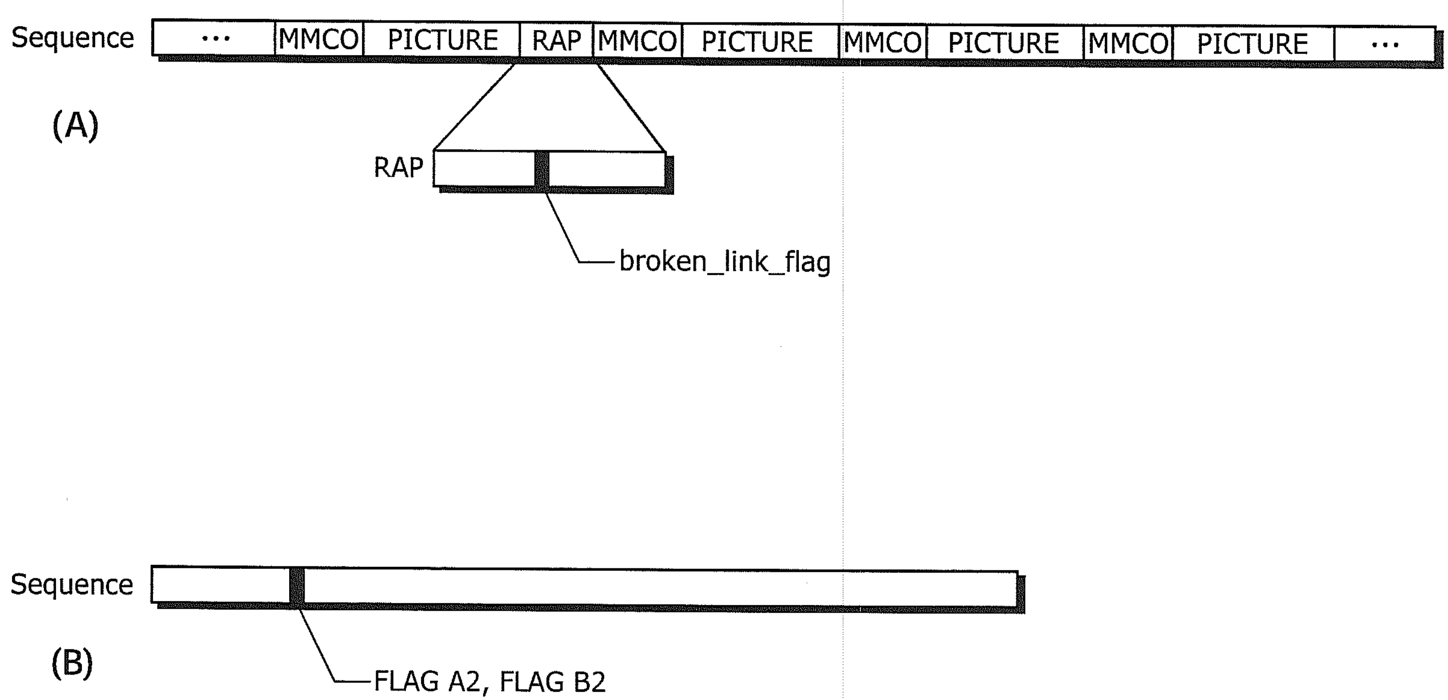
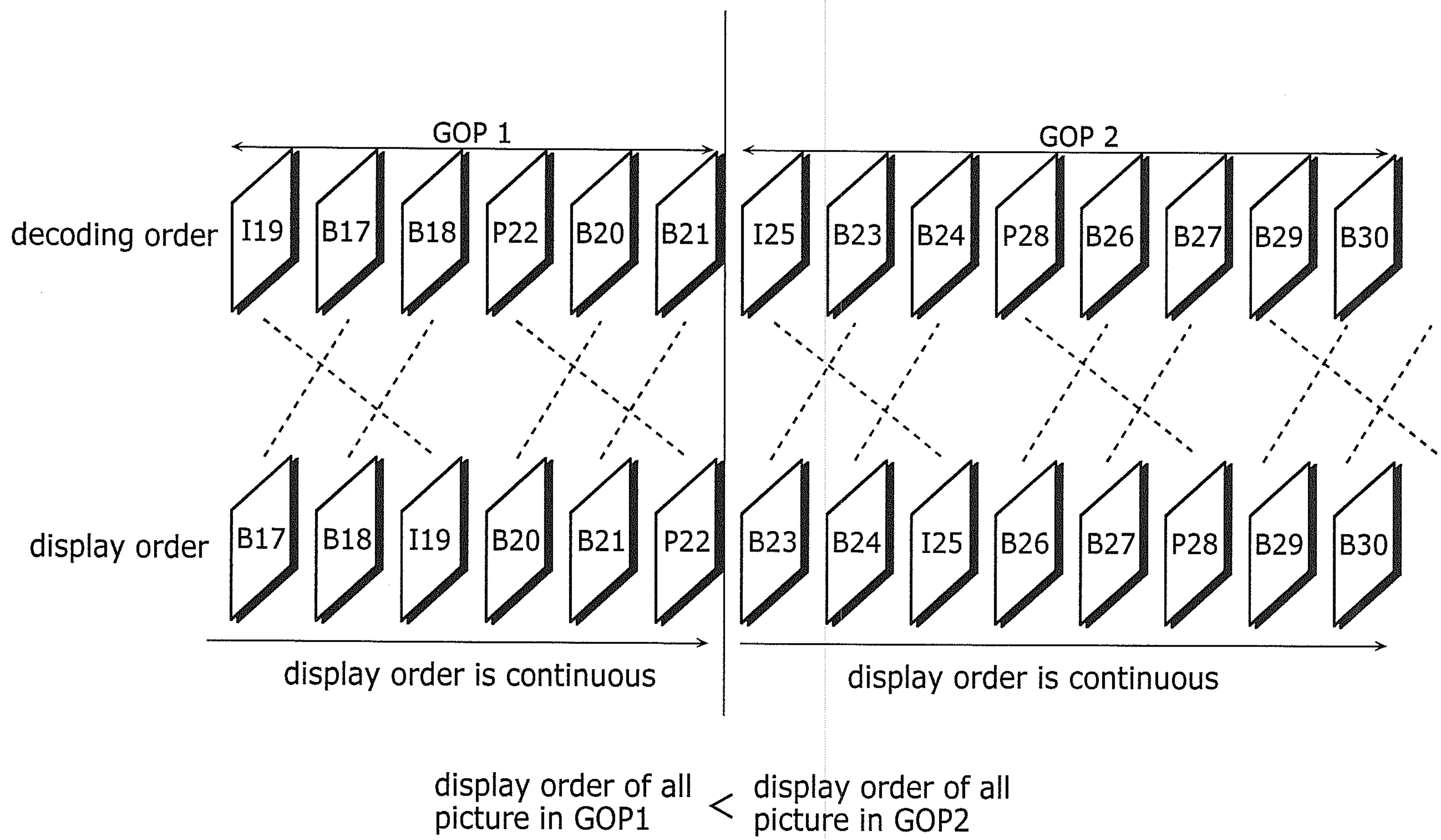
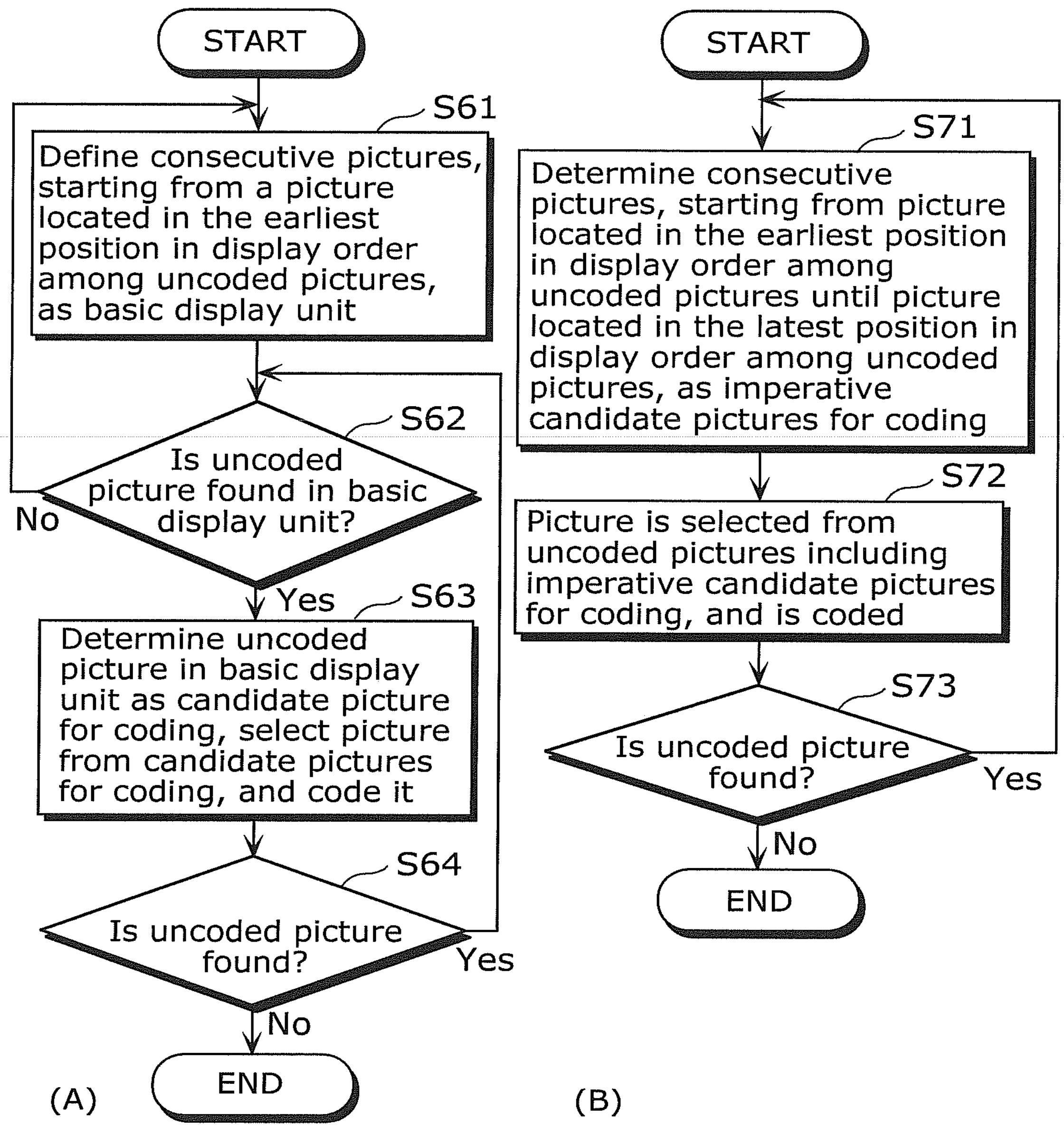

Sequence
...
MMCO
PICTURE
RAP
MMCO
PICTURE
MMCO
PICTURE
MMCO
PICTURE
...
(A)
RAP
broken_link_flag
Sequence
(B)
FLAG A2, FLAG B2

FIG. 8



GOP 1
GOP 2
decoding order
I19
B17
B18
P22
B20
B21
I25
B23
B24
P28
B26
B27
B29
B30
display order
B17
B18
I19
B20
B21
P22
B23
B24
I25
B26
B27
P28
B29
B30
display order is continuous
display order is continuous
display order of all picture in GOP1 < display order of all picture in GOP2

FIG. 9



START
S61
Define consecutive pictures, starting from a picture located in the earliest position in display order among uncoded pictures, as basic display unit
S62
Is uncoded picture found in basic display unit?
No
Yes
S63
Determine uncoded picture in basic display unit as candidate picture for coding, select picture from candidate pictures for coding, and code it
S64
Is uncoded picture found?
Yes
No
END
(A)
START
S71
Determine consecutive pictures, starting from picture located in the earliest position in display order among uncoded pictures until picture located in the latest position in display order among uncoded pictures, as imperative candidate pictures for coding
S72
Picture is selected from uncoded pictures including imperative candidate pictures for coding, and is coded
S73
Is uncoded picture found?
Yes
No
END
(B)

FIG. 10

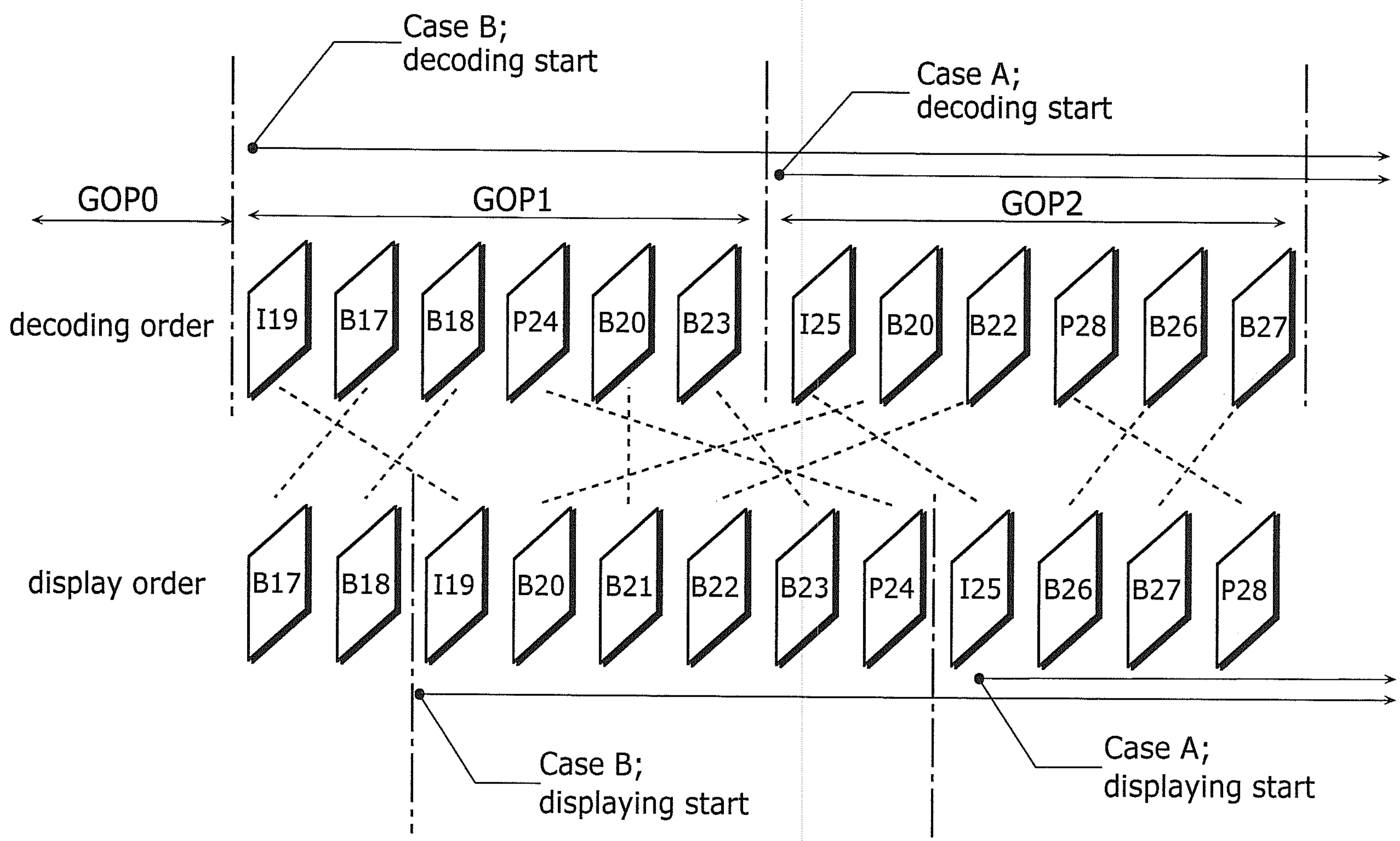

Case B;
decoding start
Case A;
decoding start
GOP0
GOP1
GOP2
decoding order
I19
B17
B18
P24
B20
B23
I25
B20
B22
P28
B26
B27
display order
B17
B18
I19
B20
B21
B22
B23
P24
I25
B26
B27
P28
Case B;
displaying start
Case A;
displaying start

FIG. 11

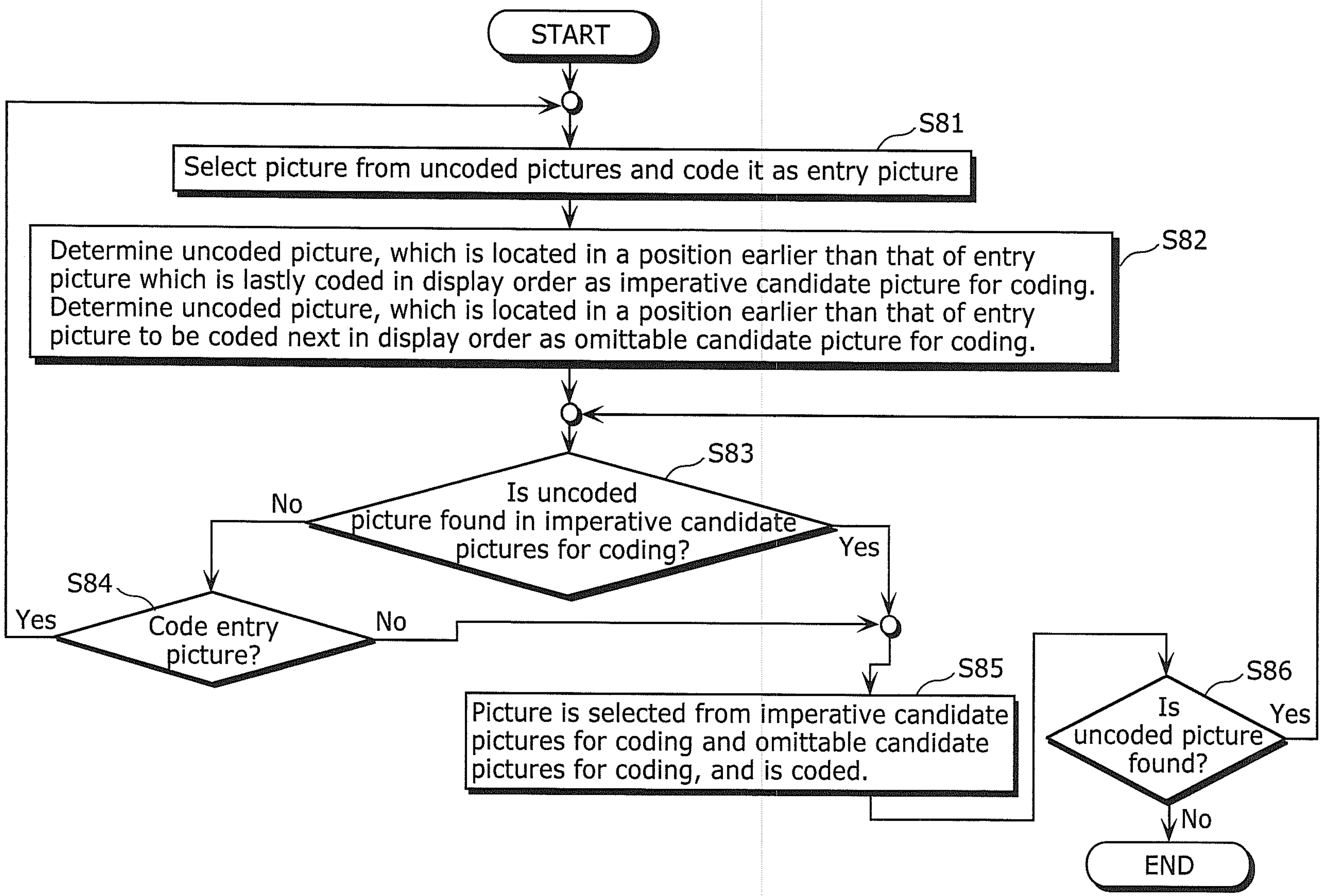
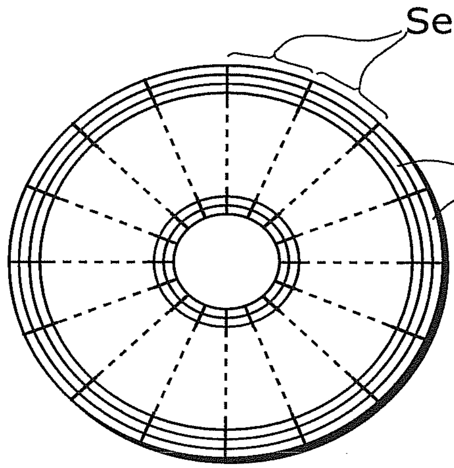
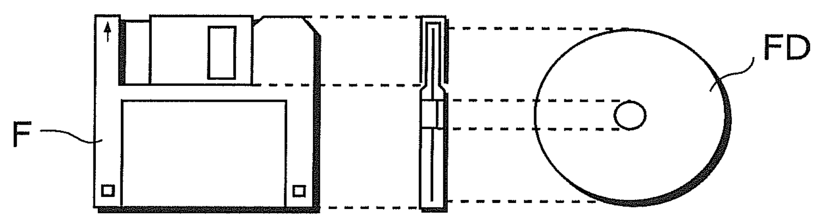

START
S81
Select picture from uncoded pictures and code it as entry picture
S82
Determine uncoded picture, which is located in a position earlier than that of entry picture which is lastly coded in display order as imperative candidate picture for coding. Determine uncoded picture, which is located in a position earlier than that of entry picture to be coded next in display order as omittable candidate picture for coding.
S83
Is uncoded picture found in imperative candidate pictures for coding?
No
Yes
S84
Code entry picture?
Yes
No
S85
Picture is selected from imperative candidate pictures for coding and omittable candidate pictures for coding, and is coded.
S86
Is uncoded picture found?
Yes
No
END

FIG. 12

(a)



(b)



(c)

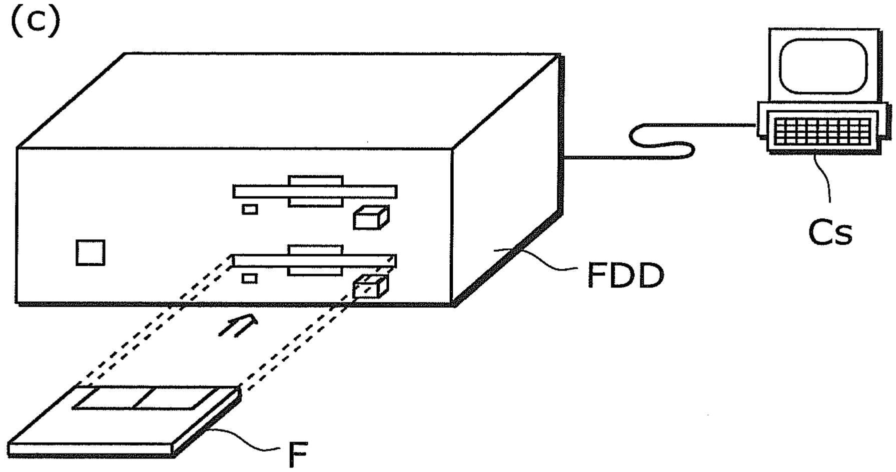
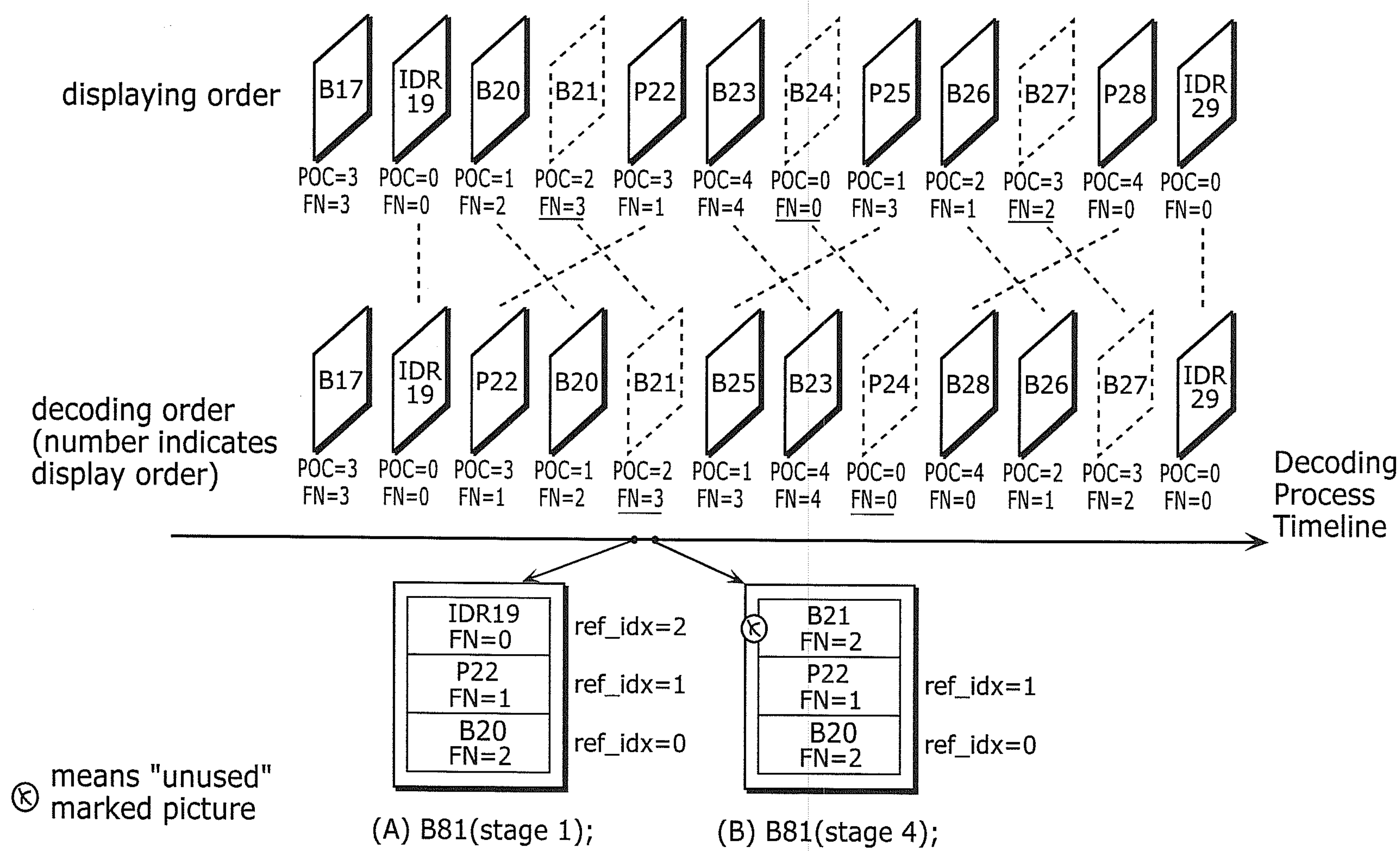
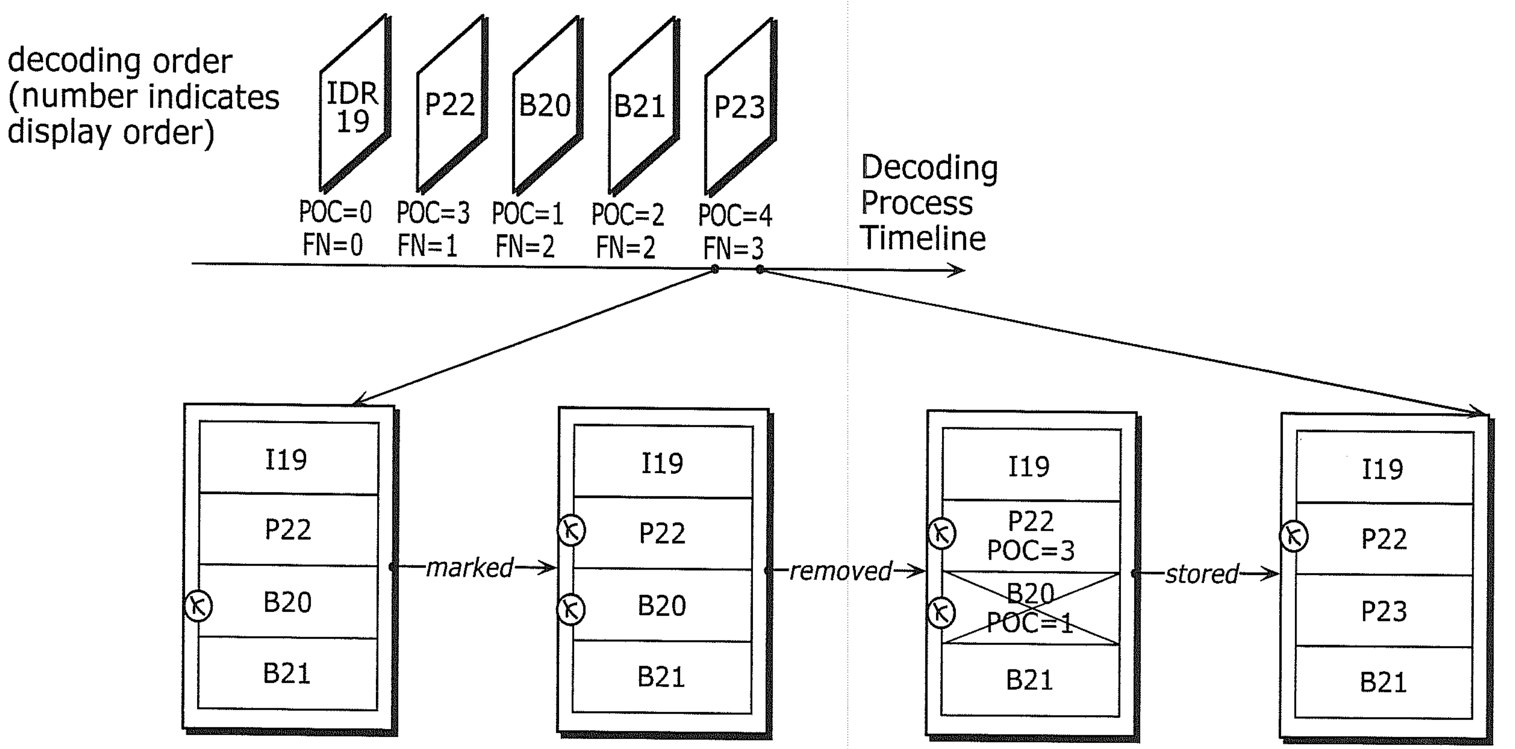


FIG. 13



displaying order
B17
POC=3
FN=3
IDR 19
POC=0
FN=0
B20
POC=1
FN=2
B21
POC=2
FN=3
P22
POC=3
FN=1
B23
POC=4
FN=4
B24
POC=0
FN=0
P25
POC=1
FN=3
B26
POC=2
FN=1
B27
POC=3
FN=2
P28
POC=4
FN=0
IDR 29
POC=0
FN=0
decoding order
(number indicates
display order)
B17
POC=3
FN=3
IDR 19
POC=0
FN=0
P22
POC=3
FN=1
B20
POC=1
FN=2
B21
POC=2
FN=3
B25
POC=1
FN=3
B23
POC=4
FN=4
P24
POC=0
FN=0
B28
POC=4
FN=0
B26
POC=2
FN=1
B27
POC=3
FN=2
IDR 29
POC=0
FN=0
Decoding
Process
Timeline
IDR19
FN=0
ref_idx=2
P22
FN=1
ref_idx=1
B20
FN=2
ref_idx=0
(A) B81(stage 1);
B21
FN=2
P22
FN=1
ref_idx=1
B20
FN=2
ref_idx=0
(B) B81(stage 4);
means "unused"
marked picture

FIG. 14



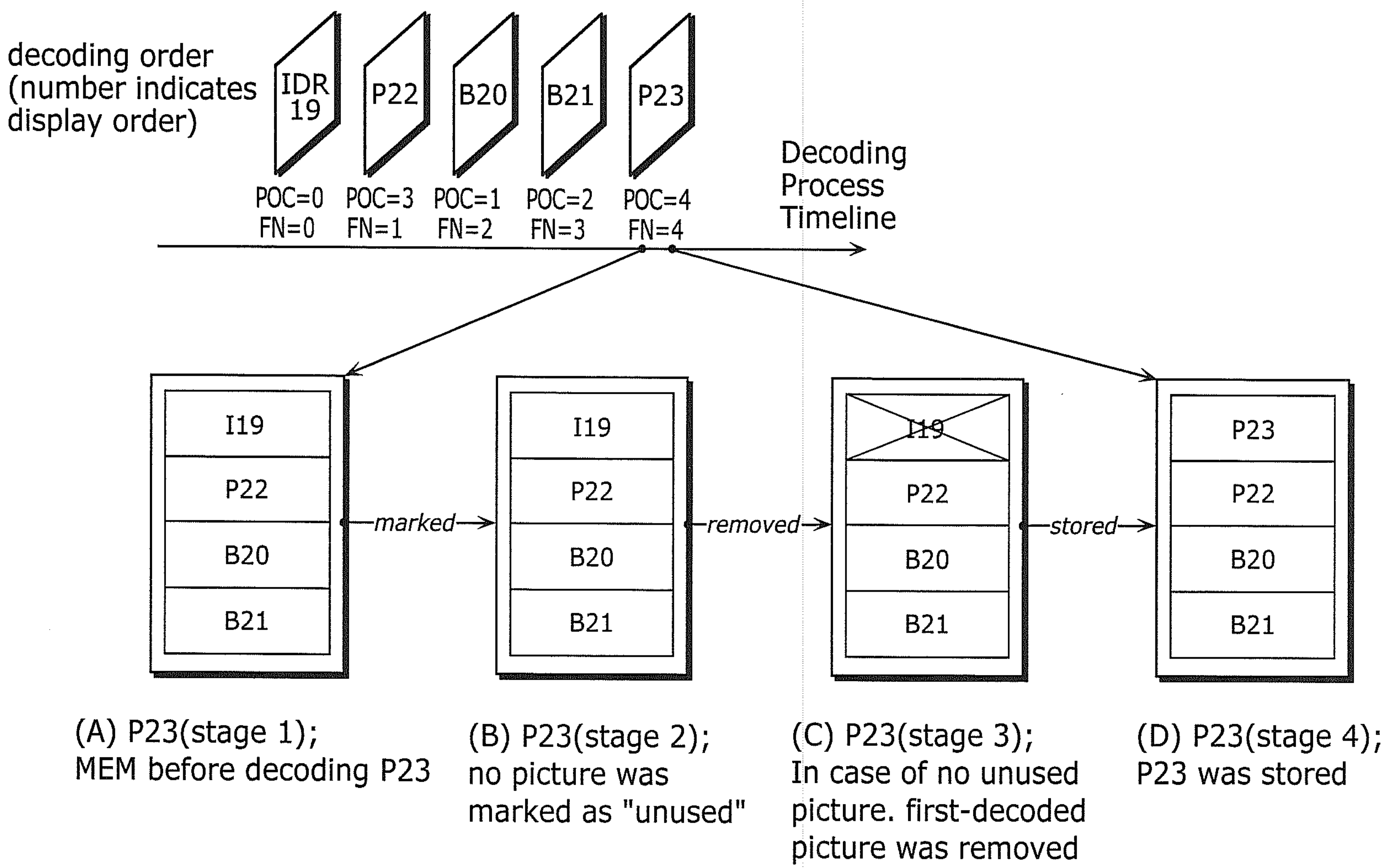
(A) P23(stage 1);

(B) P23(stage 2);
P22 was marked as
"unused"

(C) P23(stage 3);
first-display picture in
unused picture was
removed

(D) P23(stage 4);
P23 was stored

FIG. 15



decoding order
(number indicates
display order)
IDR 19
P22
B20
B21
P23
POC=0 FN=0
POC=3 FN=1
POC=1 FN=2
POC=2 FN=3
POC=4 FN=4
Decoding
Process
Timeline
I19
P22
B20
B21
marked
I19
P22
B20
B21
removed
I19
P22
B20
B21
stored
P23
P22
B20
B21
(A) P23(stage 1);
MEM before decoding P23
(B) P23(stage 2);
no picture was
marked as "unused"
(C) P23(stage 3);
In case of no unused
picture. first-decoded
picture was removed
(D) P23(stage 4);
P23 was stored

FIG. 16

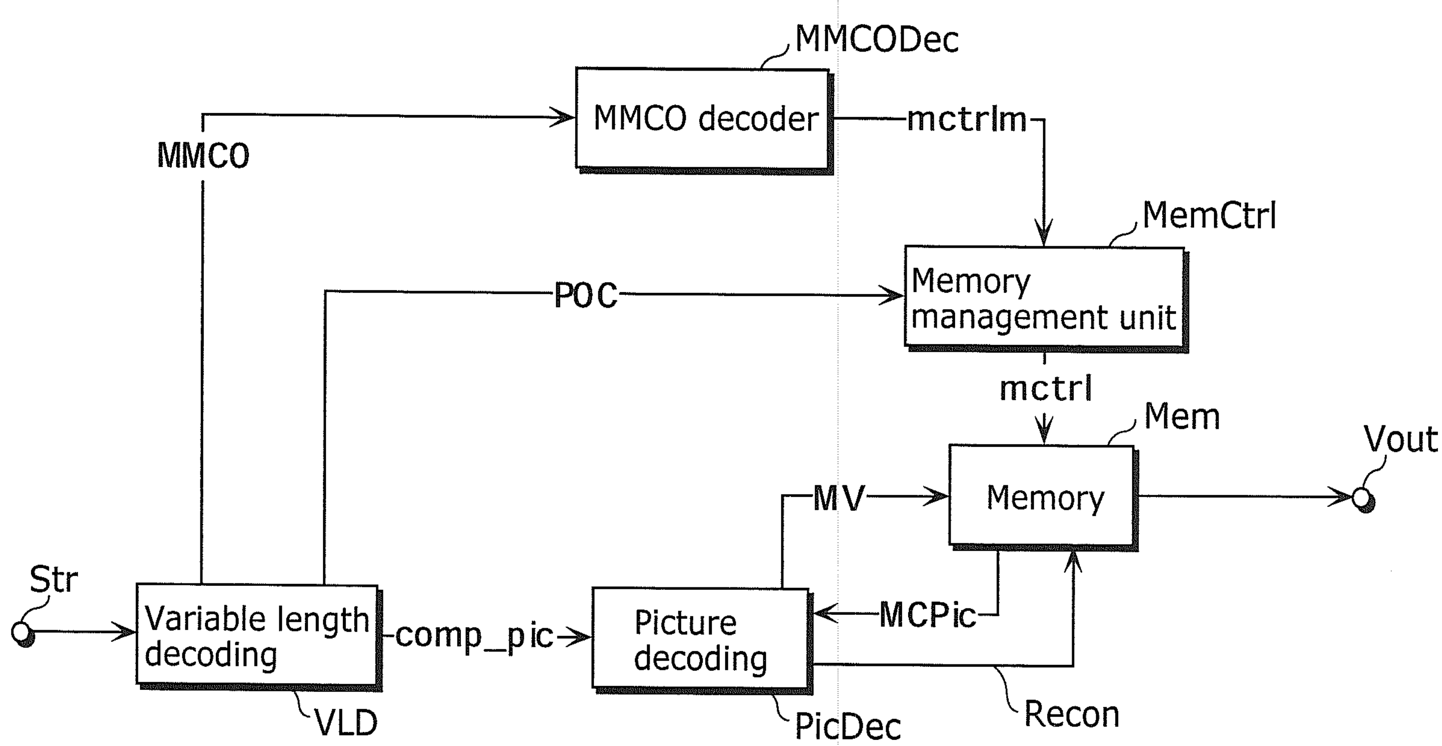

MMCODec
MMCO decoder
mctrlm
MMCO
MemCtrl
Memory
management unit
POC
mctrl
Mem
Vout
Memory
MV
Str
Variable length
decoding
comp_pic
Picture
decoding
MCPic
VLD
PicDec
Recon

FIG. 17

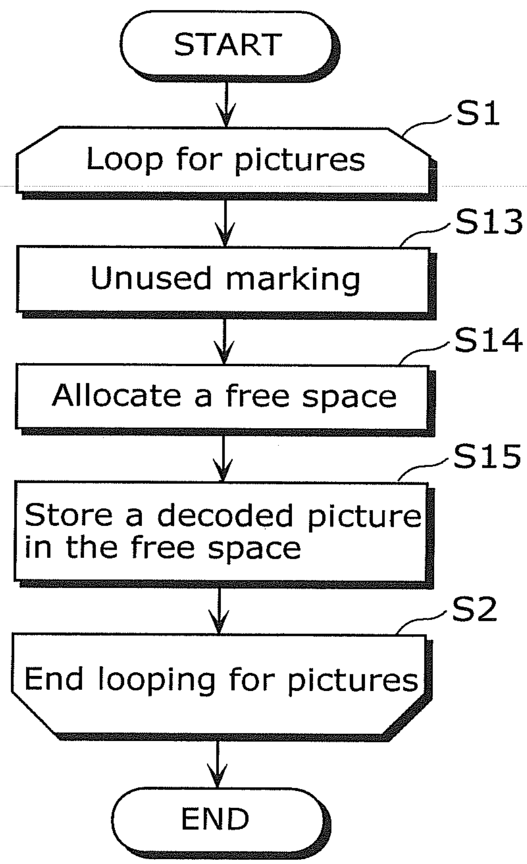

START
S1
Loop for pictures
S13
Unused marking
S14
Allocate a free space
S15
Store a decoded picture in the free space
S2
End looping for pictures
END

FIG. 18

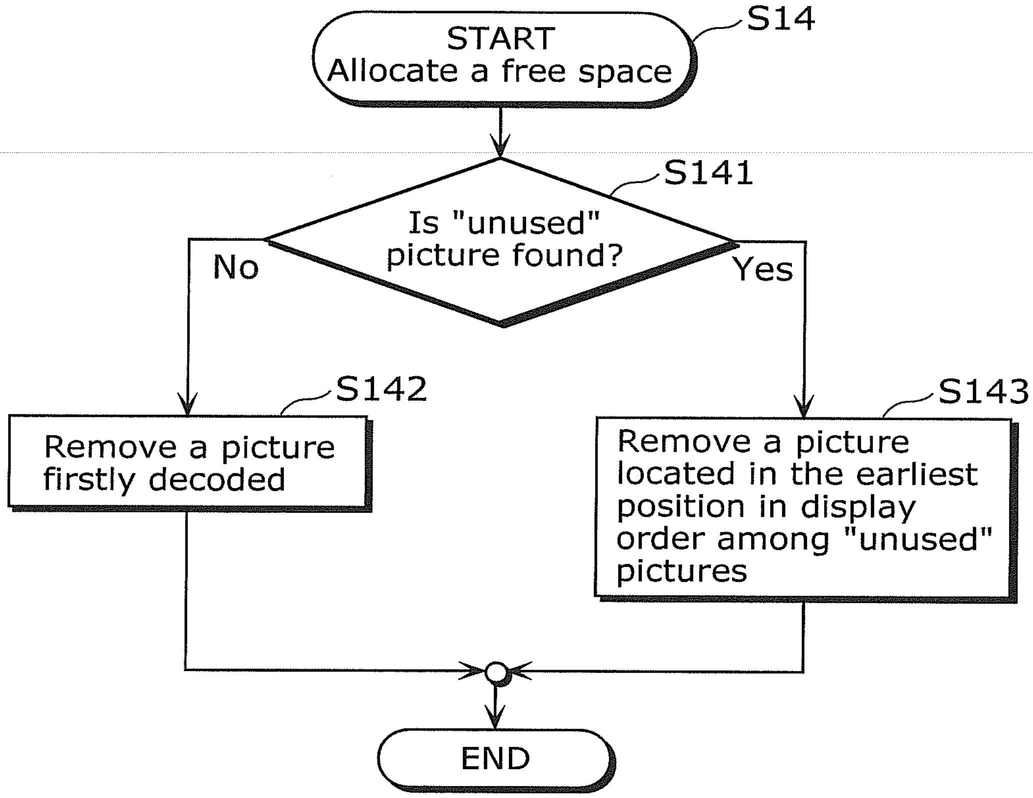
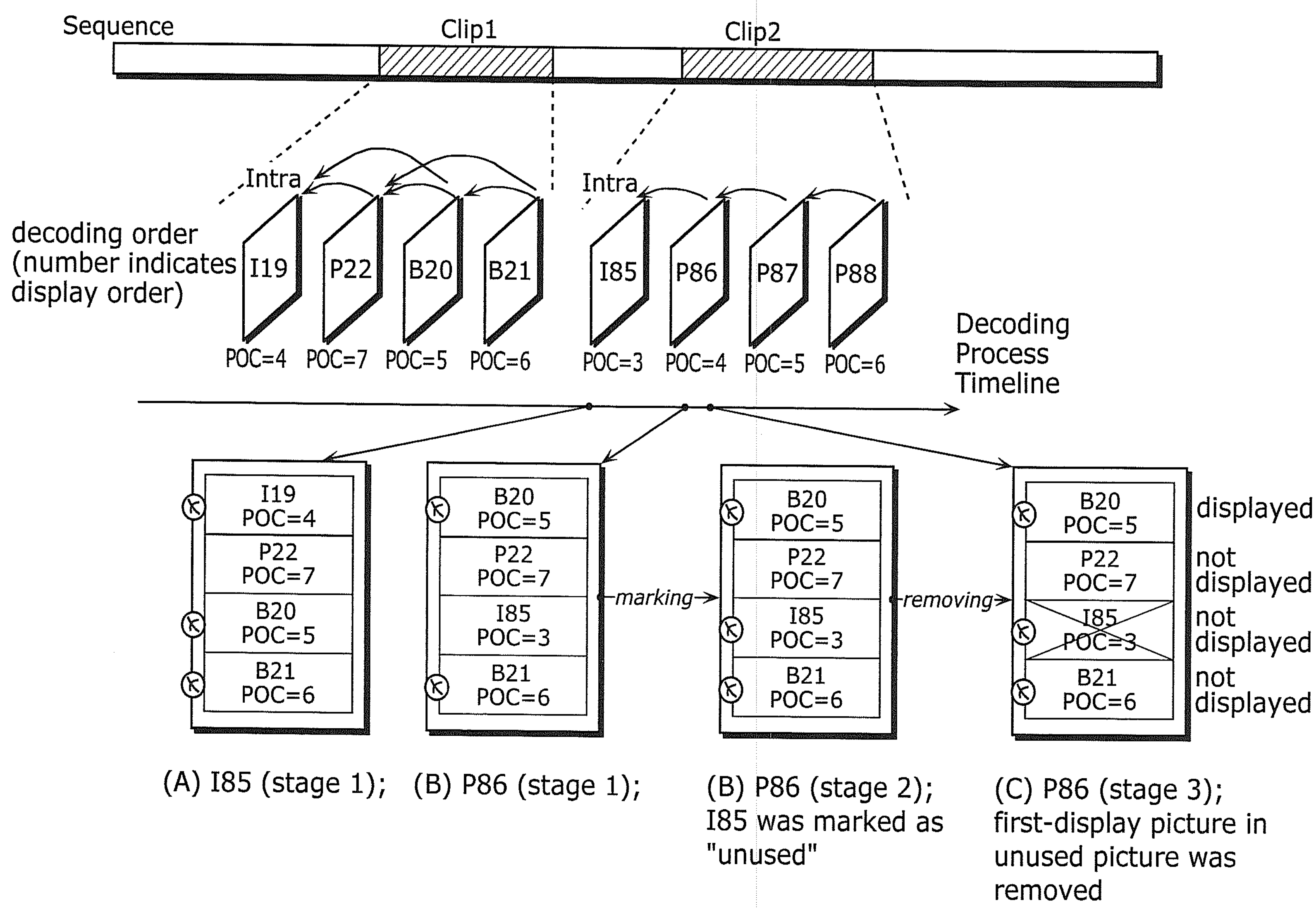
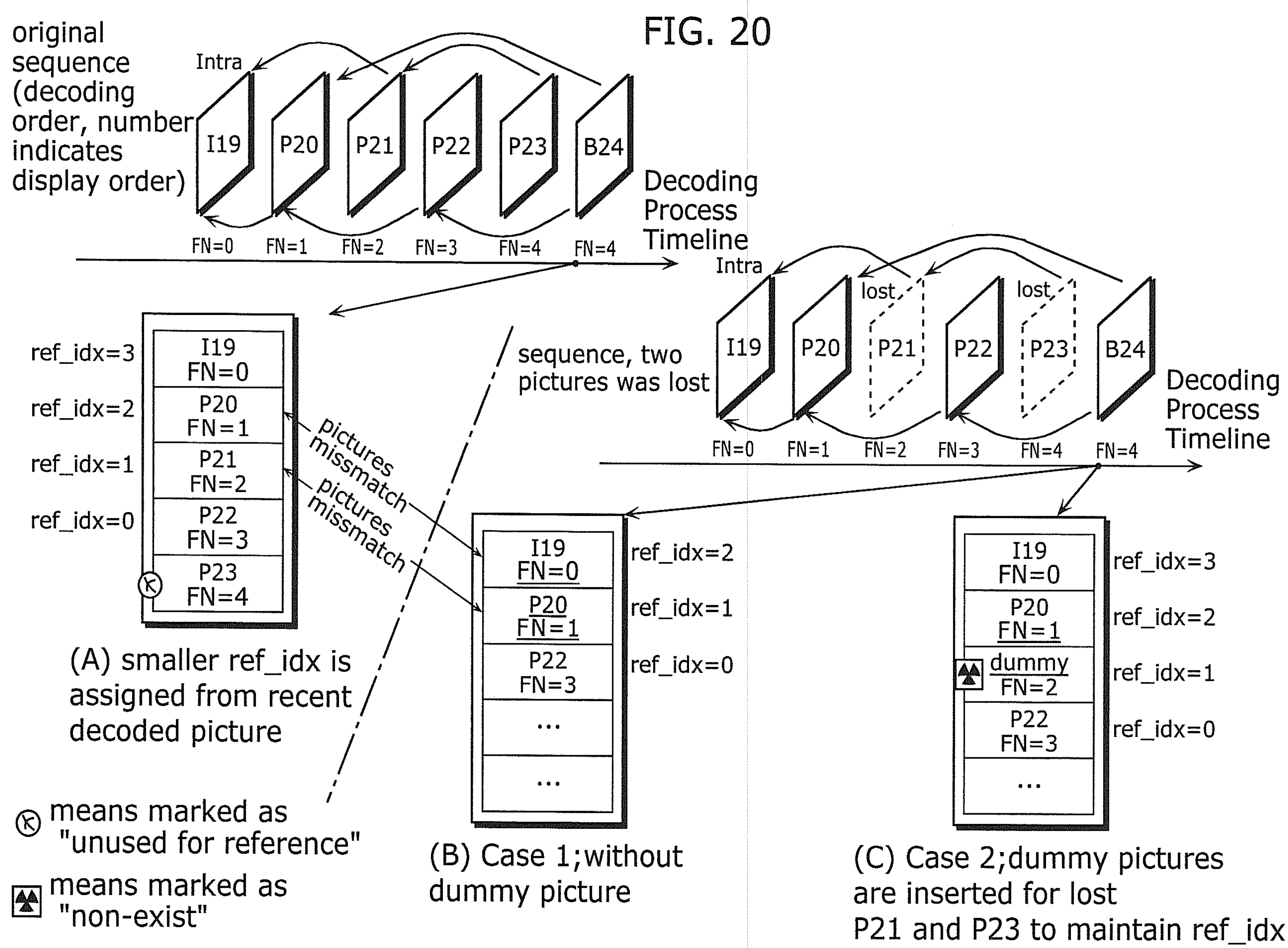

START
Allocate a free space
S14
Is "unused" picture found?
S141
No
Yes
Remove a picture firstly decoded
S142
Remove a picture located in the earliest position in display order among "unused" pictures
S143
END

FIG. 19



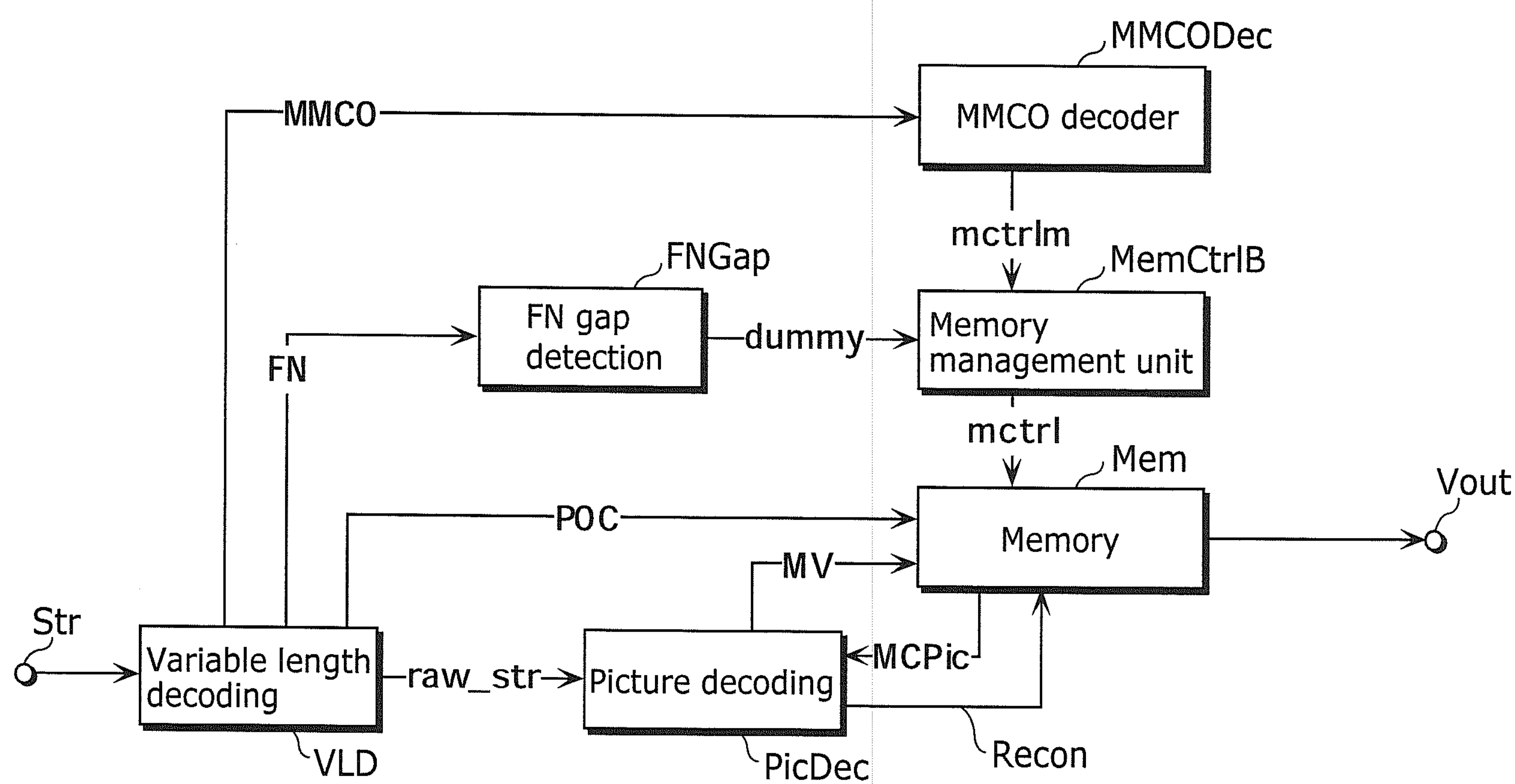
Sequence
Clip1
Clip2
decoding order
(number indicates
display order)
Intra
I19
P22
B20
B21
POC=4
POC=7
POC=5
POC=6
Intra
I85
P86
P87
P88
POC=3
POC=4
POC=5
POC=6
Decoding
Process
Timeline
I19 POC=4
P22 POC=7
B20 POC=5
B21 POC=6
B20 POC=5
P22 POC=7
I85 POC=3
B21 POC=6
marking
B20 POC=5
P22 POC=7
I85 POC=3
B21 POC=6
removing
B20 POC=5
P22 POC=7
I85 POC=3
B21 POC=6
displayed
not displayed
not displayed
not displayed
(A) I85 (stage 1);
(B) P86 (stage 1);
(B) P86 (stage 2); I85 was marked as "unused"
(C) P86 (stage 3); first-display picture in unused picture was removed

FIG. 20



original sequence (decoding order, number indicates display order)
Intra
I19
P20
P21
P22
P23
B24
Decoding Process Timeline
FN=0
FN=1
FN=2
FN=3
FN=4
FN=4
ref_idx=3
ref_idx=2
ref_idx=1
ref_idx=0
I19 FN=0
P20 FN=1
P21 FN=2
P22 FN=3
P23 FN=4
pictures missmatch
pictures missmatch
(A) smaller ref_idx is assigned from recent decoded picture
means marked as "unused for reference"
means marked as "non-exist"
sequence, two pictures was lost
lost
lost
I19 FN=0
P20 FN=1
P22 FN=3
...
...
ref_idx=2
ref_idx=1
ref_idx=0
(B) Case 1;without dummy picture
I19 FN=0
P20 FN=1
dummy FN=2
P22 FN=3
...
ref_idx=3
ref_idx=2
ref_idx=1
ref_idx=0
(C) Case 2;dummy pictures are inserted for lost P21 and P23 to maintain ref_idx

FIG. 21



MMCODec
MMCO
MMCO decoder
mctrlm
FNGap
MemCtrlB
FN gap detection
dummy
Memory management unit
FN
mctrl
Mem
Vout
POC
Memory
MV
Str
Variable length decoding
raw_str
Picture decoding
MCPic
VLD
PicDec
Recon

FIG. 22

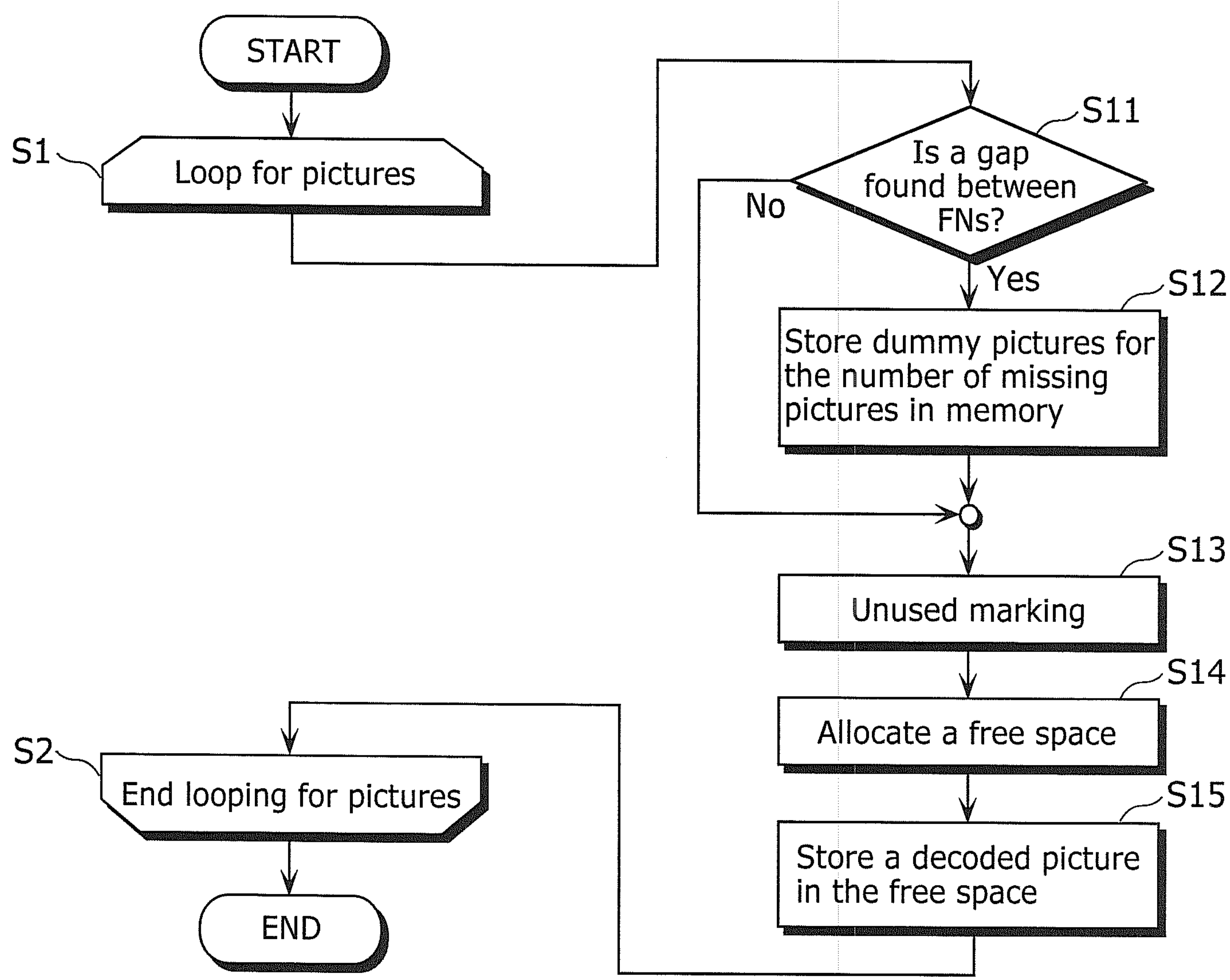
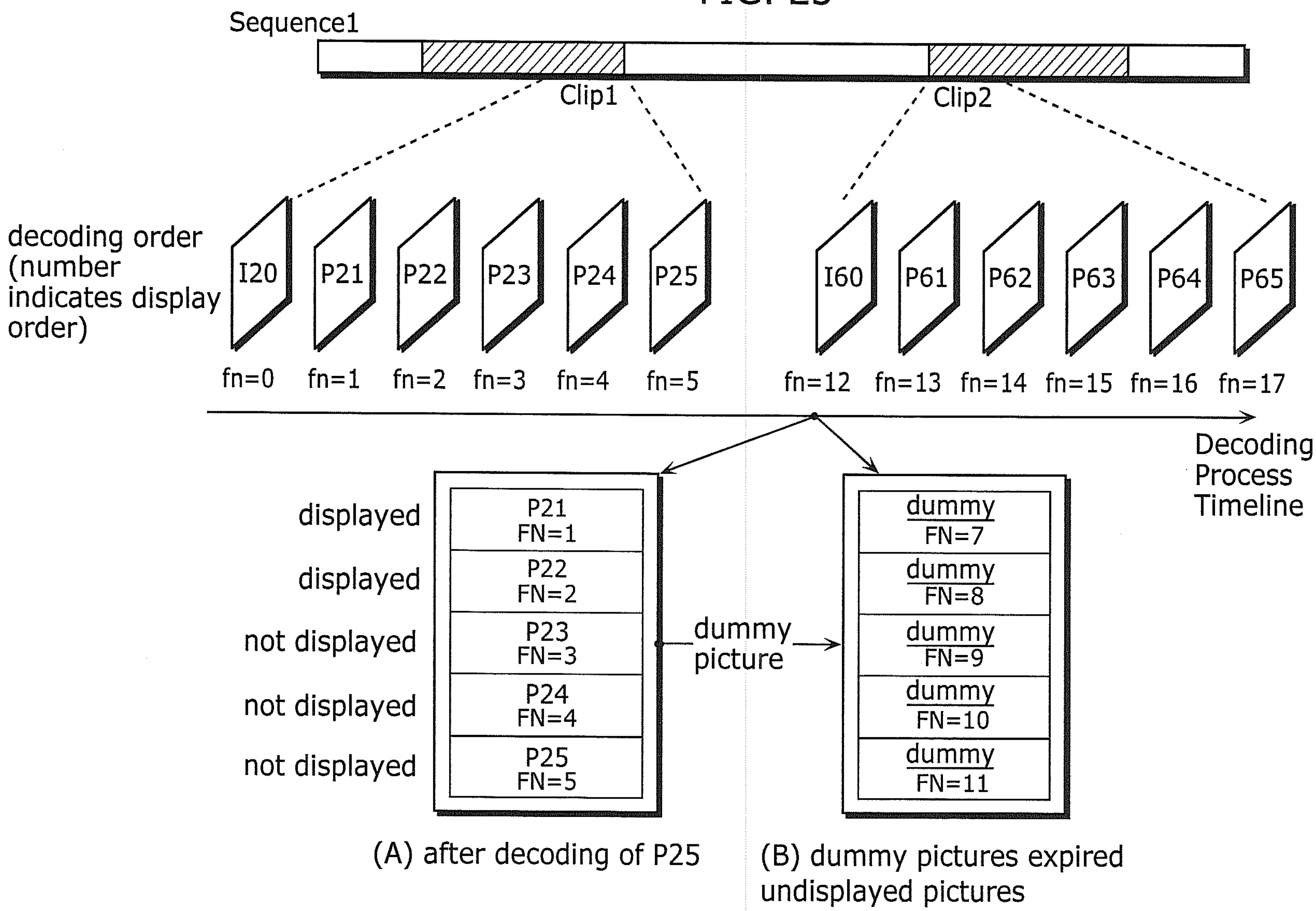
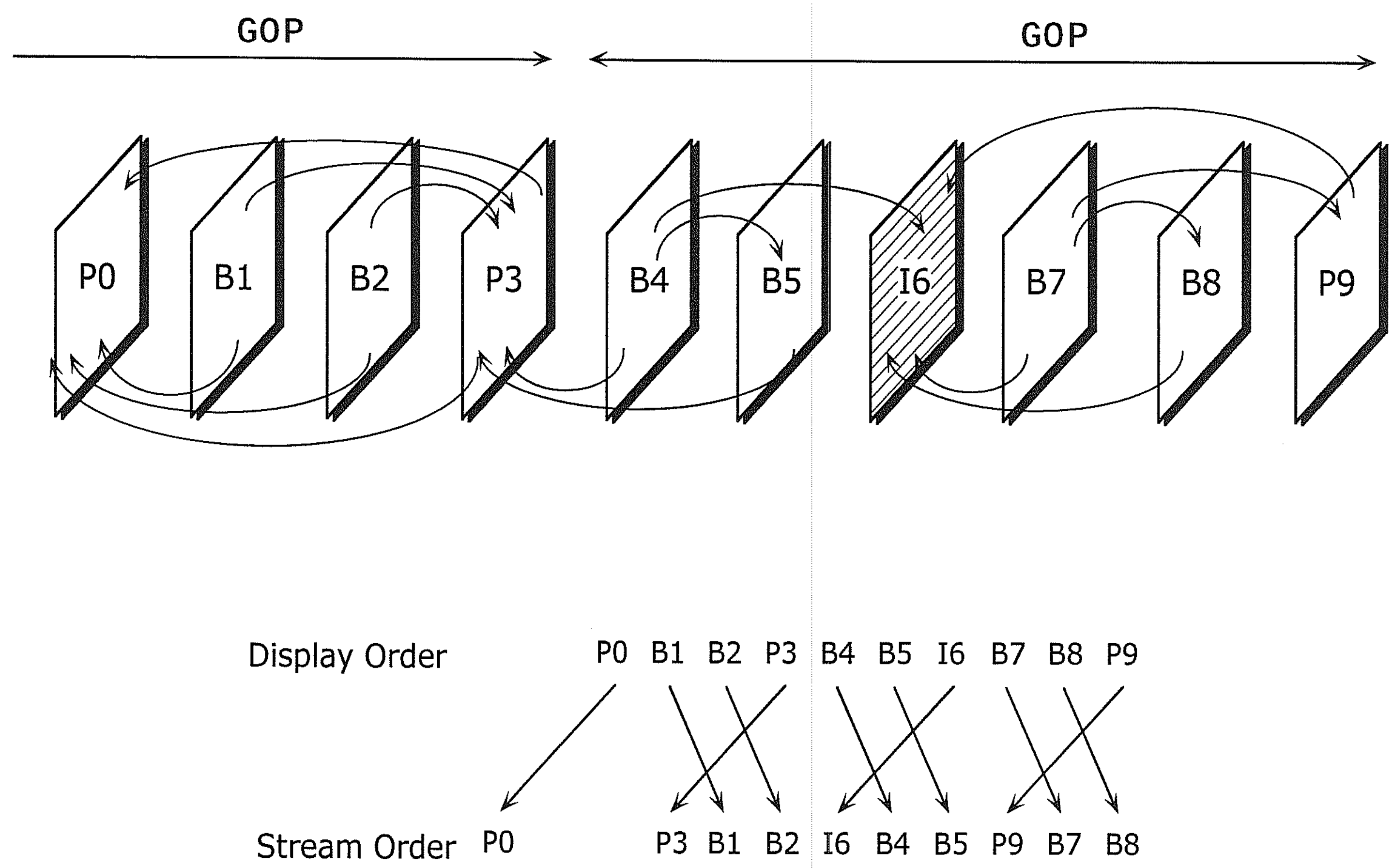

START
S1
Loop for pictures
S11
Is a gap found between FNs?
No
Yes
S12
Store dummy pictures for the number of missing pictures in memory
S13
Unused marking
S14
Allocate a free space
S15
Store a decoded picture in the free space
S2
End looping for pictures
END

FIG. 23



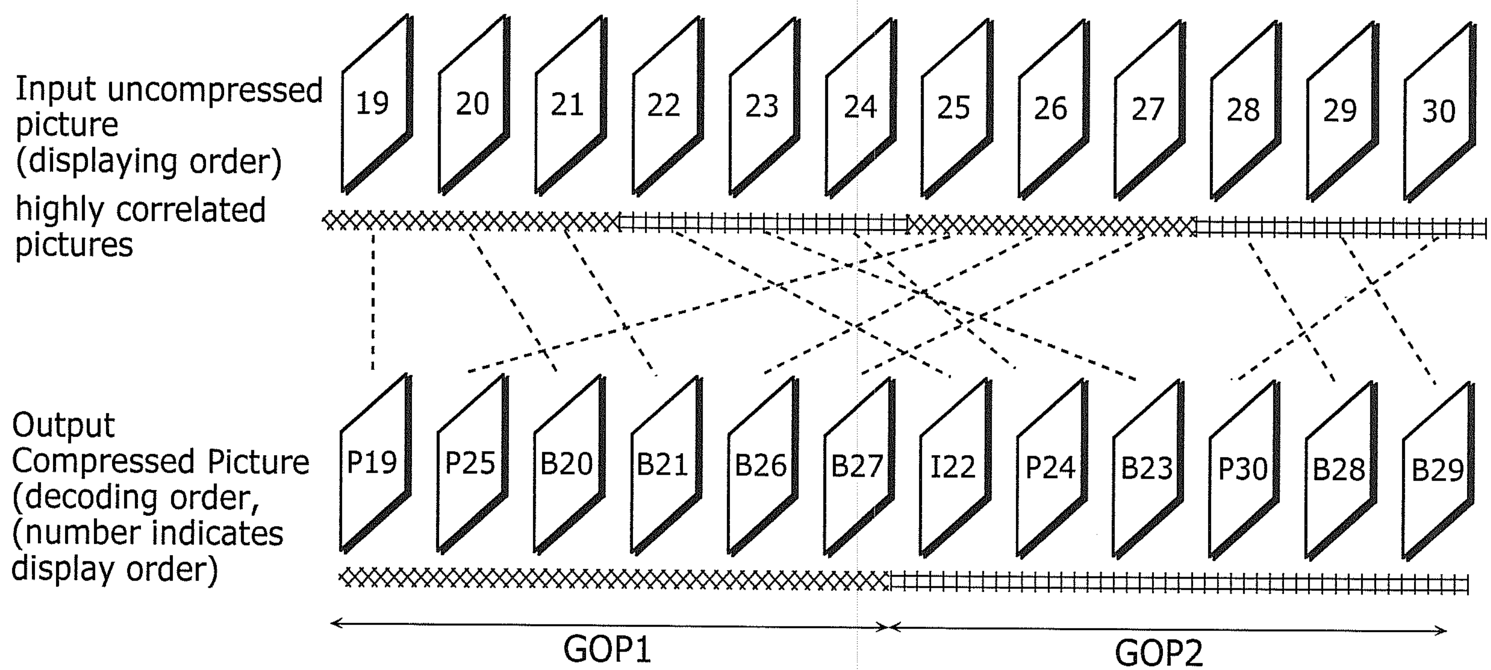
Sequence1
Clip1
Clip2
decoding order (number indicates display order)
I20
P21
P22
P23
P24
P25
I60
P61
P62
P63
P64
P65
fn=0
fn=1
fn=2
fn=3
fn=4
fn=5
fn=12
fn=13
fn=14
fn=15
fn=16
fn=17
Decoding Process Timeline
displayed
displayed
not displayed
not displayed
not displayed
P21 FN=1
P22 FN=2
P23 FN=3
P24 FN=4
P25 FN=5
dummy picture
dummy FN=7
dummy FN=8
dummy FN=9
dummy FN=10
dummy FN=11
(A) after decoding of P25
(B) dummy pictures expired undisplayed pictures

FIG. 24



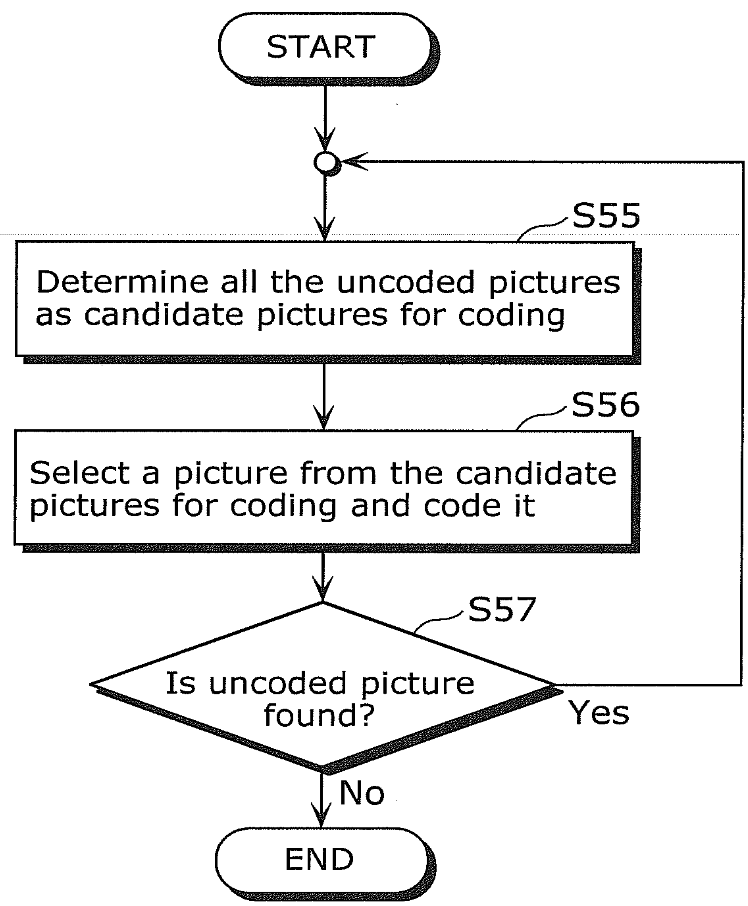
GOP
GOP
P0
B1
B2
P3
B4
B5
I6
B7
B8
P9
Display Order
P0 B1 B2 P3 B4 B5 I6 B7 B8 P9
Stream Order
P0
P3 B1 B2 I6 B4 B5 P9 B7 B8

FIG. 25



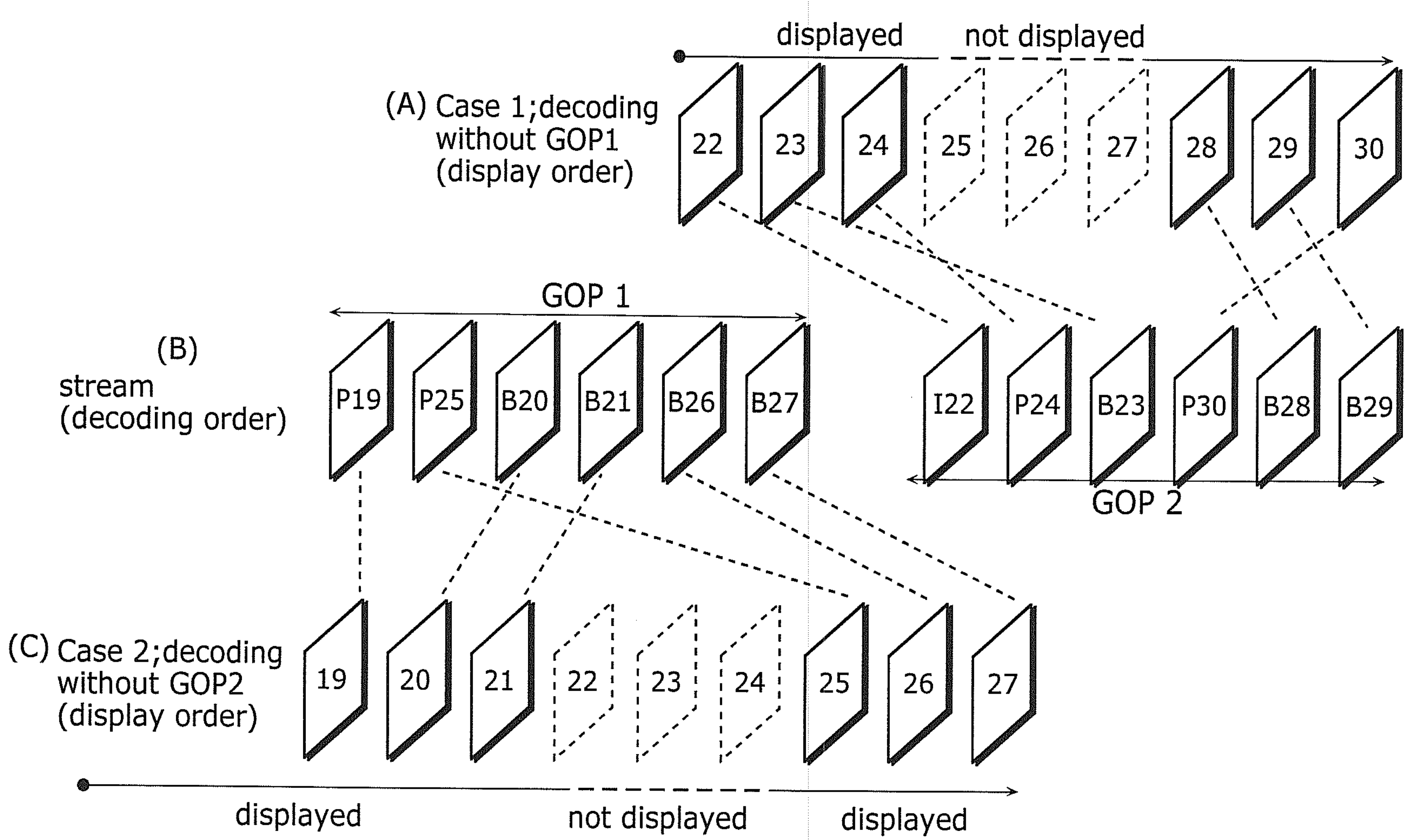
Input uncompressed picture (displaying order)
19
20
21
22
23
24
25
26
27
28
29
30
highly correlated pictures
Output Compressed Picture (decoding order, (number indicates display order)
P19
P25
B20
B21
B26
B27
I22
P24
B23
P30
B28
B29
GOP1
GOP2

FIG. 26



START
S55
Determine all the uncoded pictures as candidate pictures for coding
S56
Select a picture from the candidate pictures for coding and code it
S57
Is uncoded picture found?
Yes
No
END

FIG. 27



displayed
not displayed
(A) Case 1;decoding without GOP1 (display order)
22
23
24
25
26
27
28
29
30
GOP 1
(B) stream (decoding order)
P19
P25
B20
B21
B26
B27
I22
P24
B23
P30
B28
B29
GOP 2
(C) Case 2;decoding without GOP2 (display order)
19
20
21
22
23
24
25
26
27
displayed
not displayed
displayed